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WE INVITE PRACTICAL ARTICLES ON THE TRADE IN ALL ITS BRANCHES, WHICH WILL BE PAID FOR MSS. SHOULD BE WRITTEN ON ONE SIDE OF THE PAPER ONLY.

BRITISH FOUNDRYMEN'S ASSOCIATION.
LIST OF SECRETARIES—

General Secretary: J. E. H. Allbut, Highfield Road, Stretford, Manchester.
Manchester: A. Harrison, 705, Manchester Road, Castleton.
Birmingham: George Hailstone, 29, Grange Road, Smethwick.
Cardiff: H. Griffiths, Messrs. J. Williams & Sons, Ltd., Globe Foundry, Cardiff.
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Glasgow: W. C. Gray, Royal Technical College, Glasgow.
London: T. Murphy, 180, Gray's Inn Rd., London, W.C.
Halifax: J. G. Robinson, 17, Gibraltar Road, Halifax.
Newcastle-on-Tyne: H. A. J. Rang, Cleveland Road North Shields.

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NOTES AND COMMENTS.

The Progressive Foundry.

Could a mature foundryman of half a century ago have been present at last month's meetings of the British Foundrymen's Association, he would have experienced a series of complex emotions. For never before, in the history of the Association have the discussions been so destructive of old fallacies as those of this year's Convenntion. The foundry world, without doubt, is experiencing a relatively rapid reconstruction of its ideas; and instead of calling for the old slur of empirical and unscientific procedure, it will soon command respect and admiration as a trade which has risen from the mire of obscurity and disrepute, and placed itself upon a foundation of scientific knowledge, with its face set towards progress.

Take first the matter of cupola working, so ably dealt with in the research by Mr. Cook. How many foundrymen, even ten years ago, when the Association was formed, would have listened to the possibility of rendering the cupola amenable to rule and regulation? Very few, indeed! The cupola always has been regarded as possessing its own special vagaries of humour, and to assert that it could be governed by any process other than that of careful study of its individual eccentricities, was to assert one's ignorance of cupolas individually and generally. Now, however, that idea must go by the board, and we start with at least the basis of systematic cupola working. That the research which has established this position results from a practical man's efforts is not surprising, for the subject is one that can essentially only be properly dealt with by the practical man. That a very considerable knowledge of theoretical considerations was also a qualification for the work is yet another claim for that higher development of intelligence in our workers which is, in some quarters, now receiving careful consideration. The exigencies of industrial life in all departments demand a steady growth of intellectual capacity on the part of a large body of our workers, and will not allow the haphazard methods of yesterday to persist. We may take it as a very hopeful sign when a body such as the British Foundrymen's Association accepts for presentation at its Annual Convention a contribution on educational matters a subject which would have received scant courtesy at the hands of foundrymen a generation or two ago; and still more hopeful is the fact that the Council of the Association are giving their most serious attention to the formulation of a scheme for the systematic training of apprentices. Without doubt, an awakening is in progress. But that the foundry should be to the front in the movement! What, indeed, would our ancient foundryman say to that?

But his surprise would not end there. He would find some of his old tricks exposed and that carefully cherished secret of how to get the right metal by the sly addition of steel turnings and punchings, accepted as regular practice and its phenomena explained. On

a little reflection, however, he might really wonder why the practice has for so long remained lurking in the rear of foundry procedure, unexplained and imperfectly understood. He would tell you he dabbled in the practice twenty-five years ago, without advertising the fact; and he might also relate many anecdotes of troubles incurred through not understanding the action of such additions. Not that the subject is by any means well understood to-day; for even regular users of steel additions to cupola mixtures are still mainly working in the dark. Here it may be well to enter a protest against the very misleading term, "Semi-Steel." The iron trade generally applies the term to quite a different product, *i.e.*, to semi-manufactured steel, such as blooms, billets, etc.; but the foundryman, with his customary facility for applying inept titles, has attached it to a material which is in no respect a steel or a semi-steel, but simply a cast-iron.

Another source of wonderment to the foundryman of a few generations ago would be the suggested application of electricity to foundry work. In fact, we believe the suggestion will meet with the opposition of many orthodox founders of to-day. The iron trade has become accustomed of recent years to discussion of the electric furnace, but in connection with steel refining, and to some extent iron smelting. The iron and brass foundry is yet considered by the majority to be without the range of electric-furnace operation. True is it that, except for special work, the iron foundry may still be so considered; but the brass foundry is in quite another category. The engineer is giving increasing attention to the non-ferrous alloys and their great possibilities, and these possibilities can only be fully realised by the aid of the electric furnace, unless some other form of melting is discovered or invented which offers the same advantages. The development of non-ferrous work has now proceeded to the point where the electric furnace becomes practically a necessity if the progress is to be maintained. Eminent scientific and metallurgical authorities have for some time been insisting that melting in vacuo, or at least in a controllable atmosphere, is the only solution to many metallurgical difficulties; and we may look for a marked advance in this direction in the near future. There is still much spade work to be done, but there has already been a fair amount of ground cleared, and the pioneers will soon have the satisfaction of seeing their efforts rewarded with practical results.

It is significant that one branch of metallurgical work which has made remarkable advances during the last few years is dependent for its existence on the electrical engineer; and it would not be reasonable to assume that the aluminium alloy industry (the branch in question) will depart from the power which made it a commercial possibility. The electric furnace has given it birth and it has been none too happy with its foster parents, the fuel furnaces, into whose charge it has generally been consigned. Like the other non-ferrous alloys, those of aluminium have vast possibilities ahead, and the engineer will not long be allowed to neglect them.

There is one other form of foundry progress that calls for comment. For a number of years cast-iron has struggled against great difficulties, in the increasingly exacting requirements of engineering and the competition of its more refined relatives of the steel family. The reputation of the latter has been somewhat traded upon to the detraction of the humbler metal, so that cast-iron has in some cases been ousted and has also been driven to seek fields of application in which it was not at its best. The present movement, however, is towards bringing cast-iron to its own again. But it will also have to relinquish some fields in which it has been allowed to gain a footing. Some indication of this is given in the Paper before the Convention, touching the artistic treatment of the metal. For every class of material there is a field according to its properties—a field both in application and design; and the misapplication of cast iron in the past calls for careful consideration, that it may henceforth be given opportunity to do its best.

Reverting to the work of the British Foundrymen's Association, it is evident that as that body grows in strength and importance the scope for its activities increases. The work ahead is immense, for it has virtually to raise the whole status of the foundry trade from the poor position occupied during centuries; it has not only to foster a movement towards a higher intelligence in the trade, but to insist that founding receives at the hands of the engineer the consideration which is due to it. More exacting requirements must be accompanied by some recognition of the higher capabilities necessary to meet those requirements; and at the same time those capabilities must be developed, not only in a few of the higher foundry craftsmen, but in the rank and file workers. It is unnecessary to dilate upon the conditions and influences which have for so long operated to the detriment of foundry progress; but we may again urge the desirability—nay, the necessity—of giving the same consideration to the proper equipment of the foundry as in other departments of engineering. If such an appeal will not be heard on the grounds of common justice, let it be made on the grounds of simple commercial economy. It cannot be too frequently insisted that a foundry properly equipped and with decent working conditions for the men is a paying proposition and that the efficiency of the plant as a money-producer is gravely impaired by neglect to provide these conditions. The Association has already done much to waken public conscience to the fact that in the engineering trade, as in many other trades, there is a department which has not yet been given a fair chance; but public conscience sleeps heavily, and much shaking is required.

Nor must we neglect the necessity of reforms from within. The case is not all one for outside treatment and mere recognition of possibilities. In the present stage of transition from obscurity and humiliation to a status in keeping with its value, the foundry trade must see that it justifies the higher place accorded to it. Numerous old prejudices must be thrown aside, and finally discarded must be the idea that the foundry is not amenable to systematic procedure and standardised practice. Too long has it suffered from this misconception; but there are many evidences of a change, and a few years will see great attention being given by foundry owners to system, standardisation, and scientific procedure.

The organisation of a foundry's operations demands varied qualifications, of both engineering and business nature, and, in addition, a considerable knowledge of chemistry and metallurgy. In short, a competent foundry manager is an engineer of no mean degree, and it would be well if this were better recognised and some of the dignity associated with the calling which is attached to other branches of engineering. The term "foundry engineer" is not very familiar in this country, though it is an established degree on the Continent. But it could well be adopted here, and our technical colleges would be well advised to take the matter up thoroughly.

British Foundrymen's Association.

Annual Convention in London.

The Annual Convention of the British Foundrymen's Association was held in London, on June 21 to 24, with an exceptionally good attendance of members from all parts of the country. The sessions for the reading of Papers were held at Connaught Rooms, Great Queen Street, W.C.

The first function of the Convention was an official visit to the First Foundry Exhibition, at Agricultural Hall, Islington, N., on Saturday, June 21, and a luncheon to the members by the kind invitation of the authorities of the Exhibition. At the luncheon, Mr. F. W. Bridges, the organiser, presided, supported by Mr. Walter F. Reid, F.I,C., F.C.S., and other gentlemen. Several interesting speeches were made at the conclusion of the luncheon.

On Sunday, the programme included a trip up the River Thames, starting from Hampton Court. This function was most enjoyable, and was participated in by about 120 members and lady friends.

MONDAY'S PROCEEDINGS

A series of most interesting visits to works was arranged, and also on Tuesday evening a visit to the Coliseum Theatre. The social arrangements were mainly in the hands of the London Branch Hon. Secretary Mr. T. Murphy, to whose efforts their success was largely due.

On Monday, June 23, the first session for the presentation of Papers was held at Connaught Rooms. A general business meeting of the Association, presided over by Mr. Charles Jones (Cardiff), the retiring President, preceded the Papers.

Mr. S. A. Gimson, President of the British Foundrymen's Association, 1913-1914.

The President (Mr. C. Jones) having, on behalf of the Council, thanked the members for their attendance in such numbers, said that the Association had passed through another year of an existence which had been marked with milestones of their progress. He trusted that the Association would continue to make the same progress that it had made in the past. (Applause).

Annual Meeting.

The Annual Report of the Council and the accounts and balance sheet were taken as read and, on the motion of Mr. H. Winterton (Birmingham), seconded by Mr. B. Sperring (Portsmouth), were unanimously adopted.

The report and accounts were as follows:—

Annual Report of the Council for 1912.

The Council have pleasure in presenting to the members the following report of the progress and work of the Association during the past year :—

The respective Branches have the following members attached to them :—

	Members.	Associate members.	Associates
Birmingham.. ..	15	91	70
Halifax	21	49	60
London	43	51	15
Lancashire	33	95	31
Newcastle-on-Tyne .	25	29	22
Sheffield	29	58	17
Scottish	24	89	42

Six Council meetings have been held during the year, and members have attended from Birmingham, Cardiff, Chesterfield, Derby, Dereham (Norfolk), Gloucester, Glasgow, Horsehay (Shropshire), London, Leicester, Manchester, Sheffield, South Shields, Southampton and Luton, and matters of importance to the Association have been thoroughly discussed.

The Literary Committee are now reviewing the Papers given during the past session, and the awards for the best Papers will be published shortly. Also the glossory of technical terms issued in the last "Proceedings" which was highly appreciated by the members, will be further extended.

A Committee has been appointed to formulate a scheme for training of apprentices in the foundry. This will be issued to members at an early date.

The Council have pleasure in reporting that the Branches are doing excellent work, where many interesting Papers hae been read and discussed. The social gatherings and visits to works have been greatly enjoyed by the members,

The number on the roll of the Association at the present time is 923, consisting of 7 Hon. Lime Members, 5 Life Members, 192 Members, 462 Associate Members, 257 Associates, compared with a total number of 889 for the year 1912. During the year 27 Members, 24 Associate Members, and 26 Associates have resigned or ceased to be Members, and 26 Members, 52 Associate Members, 33 Associates have been elected.

The accounts for the year ended December 31, 1912, are now submitted, having been duly audited by Messrs. Frank Creke, Harcourt & Company,

Whitehall Chambers, Colmore Row, Birmingham, the Auditors appointed by the Council.

The total revenue for the year was £352 19s. 7d., and the expenses £363 4s. 10½d., leaving a deficit of revenue over expenditure of £10 5s. 3½d. With the balance of £140 9s. 6d. brought forward from the year 1911, this leaves a balance in hand of £130 4s. 3½d.

Nine Members of the Council are retiring, and with the exception of Mr. Kenyon who has resigned, are eligible for re-election. Messrs. C. Heggie and J. Ellis retain their seats as *ex-officio* members of the Council, being Presidents of the Birmingham and London Branches respectively. The following gentlemen have been nominated:—J. E. H. Allbut, Messrs. The British Westinghouse Electric and Manufacturing Company, Manchester; *W. F. Bagnall, Shalesmoor Foundry, Sheffield; *G. Hailstone, Messrs. Averys, Limited, Smethwick; *H. Jewson, M.Inst. Mech. E., Messrs. Dobbies, Limited, East Dereham; *H. Pemberton, Midland Railway Company, Derby; *M. Riddell, Etna Ironworks, Falkirk; *T. Swinden, B.Met., Messrs. S. Fox & Company, Sheffield; T. F. Hardyman, Nautilus Works, Yeovil; A. Harrison, Castleton, Lancs.; J. G. Robinson, Halifax; H. Sherburn, Warrington; J. B. Tattersall, Handsworth, Birmingham; R. Woods, Messrs. J. Tyler & Sons, Limited, London; and J. Worrall, Commercial Cars, Limited, Luton.

At the request of the Members, the Annual Meeting was held in Cardiff on August 6, 7 and 8, when seven Papers were read and discussed. Visits to the Works of Messrs. Keen, Guest & Nettleford, Limited, the Docks of the Cardiff Railway Company, and the Penarth Docks, and Hydraulic House of the Taff Vale Railway Company were highly appreciated by the Members; and picnic to the Wye Valley terminated a very successful and enjoyable meeting.

Election of Officers.

The retiring President said that the next part of their business was the election of officers. First, however, he must thank them most sincerely for having put him in the chair for the past year, an honour which he appreciated to the full. His term of office expired that day—for which he was very sorry—and he had very great pleasure in proposing that their Senior Vice-President, Mr. S. A. Gimson, be asked to occupy the chair for the coming year. (Applause). They all knew Mr. Gimson, his earnestness and his attention to the business of the Association, and they must remember that Mr. Gimson had a great deal of time to spend in promoting the welfare of the Association. He felt sure that Mr. Gimson would do that, and would give everyone satisfaction during his term of office. Therefore, he had great pleasure in proposing Mr. Gimson's election as President. (Applause).

Mr. F. J. Cook, in seconding the nomination, said that he had very great pleasure in doing so. He felt quite sure that the election of Mr. Gimson to the Presidency would be a most important milestone in the progress of the Association, and that under his direction they would make vast strides, and more important strides, even than they had made in the past.

The proposal being unanimously carried, Mr. Gimson took the chair, and thanked the members very heartily for doing him what he regarded as a very great honour. Mr. Jones had spoken of one qualification, the mention of which struck him (Mr. Gimson) as a little back-handed. It was true that he was out of business, but his experience had been that since that occurred he had been working harder than he ever worked before, but was having no money for it. (Laughter and applause.) Mr. Gimson concluded by proposing that Mr. W. Mayer, of Dumbarton, the Junior Vice-President of last year, be Senior Vice-President for this year. They all, he said, knew Mr. Mayer, and there was no need to talk about him, but he might say that he heard Mr. Mayer on Sunday speak about himself as an enthusiastic foundryman. (Laughter). That was the kind of man they wanted as Senior Vice-President and future President. (Applause).

Mr. H. Pilkington, in seconding the nomination, said that they all recognised Mr. Mayer's ability and great practical knowledge. (Hear, hear).

Mr. Mayer, having been unanimously elected, expressed his thanks, promising to do everything in his power to promote the success of the Association. (Applause).

Mr. J. Smith (South Shields), in proposing the election to the junior Vice-Presidency of Mr. J. Ellis of Luton, said that Mr. Ellis had been a member of

Annual Dinner of British Foundrymen's Association; London Convention, 1913.

* Retiring Members.

the Council for some years, and from what they knew of him they could be sure that they could not select a better man. (Hear, hear).

MR. R. BUCHANAN (Birmingham), in seconding the motion, said that he was confident that Mr. Ellis would fulfil the greatest expectations of all the members. (Applause).

MR. ELLIS, in thanking the members for his unanimous election, said that he regarded it as a mark of their special confidence, inasmuch as the Junior Vice-Presidency was regarded as the first step to the Presidency. (Applause).

The Secretaryship.

The PRESIDENT said that the next nomination was that for the Secretaryship. He was very sorry to have to call upon Mr. Allbut to propose it, because Mr. Allbut had been their secretary for some years, and had done his work so well, that not only the members of the Council who knew his work best, but the other members would be sorry to hear that Mr. Allbut found himself called upon to retire. Mr. Allbut had put his heart into the work, but now found it difficult to give the necessary time to it,

British Foundrymen's Association—Ninth Annual Balance Sheet, 1912.

INCOME.
January 1st to December 31st, 1912.

	£ s. d.	£ s. d.
By Subscriptions received, viz.:—		
Arrears, 1911—		
1 at 21s.	1 1 0	
3 at 10s. 6d.	1 11 6	
1 at 7s. 6d.	0 7 6	
2 at 3s.	0 6 0	
		3 6 0
Subscriptions, 1912–13—		
161 at 21s.	169 1 0	
316 at 10s. 6d.	165 18 0	
1 at 10s.	0 10 0	
7 at 7s. 6d.	2 12 6	
153 at 3s.	22 19 0	
	361 0 6	
Less Subscriptions paid in advance—		
7 at 21s.	7 7 0	
9 at 10s. 6d.	4 14 6	
10 at 3s.	1 10 0	
	13 11 6	347 9 0
Bank Interest—General Account	1 17 2	
Bank Interest—Halifax Branch	0 1 5	
		1 18 7
Sale of Books		0 6 0
Balance being excess of Expenditure over Income for the Year		10 5 3½
		£363 4 10½

EXPENDITURE.
January 1st to December 31st, 1912.

	£ s. d.	£ s. d.
To Postages		18 10 2
Printing and Stationery, including Printing of Proceedings		126 3 9
Council Expenses		10 4 9
Expenses Newcastle Inaugural Meeting		9 10 0
Branch Expenses, viz.:—		
Birmingham	10 10 8	
Manchester	14 5 10½	
Sheffield	14 18 3	
Scottish	18 10 0	
Halifax	9 16 2	
London	34 16 7	
Newcastle	18 8 2	
		121 5 8½
Expenses Annual Meeting	7 8 6	
Expenses Annual Audit	3 2 0	
		10 10 6
Clerical Assistance, 1911–12		25 0 0
Honorarium to Secretary		42 0 0
		£363 4 10½

ASSETS.

	£ s. d.	£ s. d.
Cash in hand of Branch Secretaries, viz.:—		
Manchester	5 19 5	
Sheffield	11 14 2½	
Scottish	39 7 0	
Halifax	4 12 7	
General Secretary	6 0 0	
	67 13 2½	
Less Balance due to	£ s. d.	
Birmingham	6 6 11½	
London	0 6 2	
Newcastle	3 8 2	
	10 1 3½	
		57 11 11
London City and Midland Bank, Ltd.		72 12 3½
		£130 4 2½

LIABILITIES.

	£ s. d.	£ s. d.
Subscriptions paid in advance		13 11 6
Surplus as at 31st December, 1911	196 7 2	
Less Cost of Printing 1911 Proceedings	69 9 2	
	126 18 0	
Less Excess of Expenditure over Income for year ended 31st December, 1912	10 5 3½	
		116 12 8½
		£130 4 2½

NOTE.—There are arrears of Subscriptions amounting to £96 3s. 0d., which are not included in these accounts.

F. W. FINCH, *Treasurer*. J. E. H. ALLBUT, *Secretary*.

MR. MAYER proposed the re-election of the Hon. Treasurer, Mr. F. W. Finch, and recalled his first meeting with Mr. Finch, at Manchester, when the Association was formed. They all owed Mr. Finch, he said, a deep debt of gratitude for what he had done for foundrymen in helping to bring them together, and hoped that Mr. Finch would long continue to be spared to be re-elected to the position of Treasurer. (Applause).

MR. FINCH was unanimously re-elected, and in returning thanks, promised to do his best for the Association as long as he lived. (Applause). With regard to the accounts, there was an excess of about £10 in expenditure over income for the past year, but that was due to the fact that the printing of two years' "Proceedings" came into that one year's accounts.

and, in fact, had been for two or three years asking that he might retire. They parted with Mr. Allbut, as secretary, with much regret, but they hoped to have him still working with them in another capacity. (Applause).

MR. ALLBUT thanked the President for his kind remarks, and said that he had pleasure in proposing that Mr. E. A. Pilkington, of Sheepbridge, be appointed Secretary. They might have confidence that Mr. Pilkington would do the work to their satisfaction; he was a young man, and had ample time on his hands, and that was very important, for their Association had grown very rapidly. In fact, they really ought to have a Secretary who would devote the whole of his time to the Association, but at present their financial position would not enable them to do that.

The PRESIDENT said that he wished to have the pleasure of seconding the nomination. He felt certain that Mr. E. A. Pilkington, who was the son of one of their Past-Presidents, would do exceedingly useful and good work. He quite agreed with Mr. Allbut that they ought to have a secretary who could give his full time to the Association. (Hear, hear).

MR. C. JONES, PAST-PRESIDENT, 1912-13.

MR. J. SMITH (South Shields) said that he did not quite know the procedure in electing a Secretary, but he thought it would have been better to have obtained the opinion of the members, most of whom had come there knowing nothing of the resignation and nothing about the proposed new Secretary. (Hear, hear). Mr. Pilkington might be the best man possible for all they knew, but he thought that such propositions ought to come before the Branches.

After some discussion the motion was carried unanimously

MR. E. A. PILKINGTON thanked the members for the honour conferred upon him, assuring them that he would do his best for the interests of the Association. (Applause).

The New Council.

The meeting then proceeded to the election of nine Council members out of eleven candidates.

The ballot for the election of the Council resulted in the election of the following:—Messrs. H. Pemberton (M.Rly. Company, Derby), J. E. H. Allbut (Manchester), M. Riddell (Falkirk), J. G. Robinson (Halifax), T. Swinden (Sheffield), W. F. Bagnall (Sheffield), H. Jewson (East Dereham), J. B. Tattersall (Birmingham), and H. Sherburn (Warrington). The new members are Messrs. Allbut, Robinson, Tattersall and Sherburn.

Professional Auditors Appointed.

The President said that the Council recommended that the Association should formally appoint professional auditors, and had had the accounts presented this year audited by Messrs. Frank Creeke, Harcourt and Company, of Birmingham, and the suggestion was that the members now should appoint this firm—unless they wished to have another firm appointed.

MR. F. J. COOK, in proposing the appointment suggested by the President, said that at that important juncture, when they were having a change of secretaries, and in view of the growing importance of the Association and of its finances, that they should have a new system of book-keeping, and have the accounts submitted to a professional auditor. It was really due to the members that they should have a proper check kept upon their finances. The auditors had already suggested many alterations in their method of book-keeping, and the Finance Committee felt that this would be a saving of time and an advantage to them. It was desirable that their auditors should be a firm of good standing; and the firm in question had been recommended to them as holding a very high position in the financial world.

MR. MACE seconded the motion, which was carried unanimously.

Branch Representatives on the Council.

MR. RIDDELL (Glasgow) moved a resolution of which he had given notice, with regard to elections to the Council. He said that as their Association had now grown to rather large dimensions and had Branches all over the country, it was felt that the members of those Branches should have direct representation on the Council. He therefore moved an alteration of Rule 9, so as to provide that the Council should consist of delegates from each Branch, together with 10 members elected as at present, and the President, Vice-Presidents, the Past Presidents and the Presidents of branches, ex-officio members as at present.

MR. W. MAYER, SENIOR VICE-PRESIDENT.

MR. J. W. HORNE (London) seconded the proposition, on which he thought they would be practically unanimous. It seemed to him that to increase the representation of the Branches would be a good

thing. It was not that the Branches had not been represented before, because the President of every Branch was ex-officio a member of the Council, in addition to which they had by a resolution of the Council given the secretaries of all the branches right to attend the Council Meetings. This showed that the Council had been trying to keep in touch with the Branches. (Hear, hear).

The motion was carried unanimously.

MR. RIDDELL then moved the adoption of a further addition to the rules providing that each Branch shall elect, prior to the Annual General Meeting, a delegate or delegates to the Council, each Branch being entitled to elect one Councillor or more in the proportion of one to every fifty members in the Branch. A Branch, however small, he pointed out, would be able to elect one Councillor and by allowing the larger Branches to elect more than one, they would enable the Council to increase automatically as the strength of the Association increased.

MR. J. E. H. ALLBUT, RETIRING SECRETARY.

MR. F. J. COOK seconded the motion, which he thought was a very good one, inasmuch as the Branches which had the greatest stake in the prosperity of the Association would have the greatest number of representatives. Now that the members were scattered over the British Isles, it was desirable that the Council should be kept more closely in touch with them, and he thought the proposed change would add to the life and importance of the Association.

MR. HORNE said that they had also a resolution from the Sheffield Branch on this subject. He would suggest that this should be incorporated in Mr. Riddell's resolution. The Sheffield proposition was that the secretaries of Branches should be members of the Council. The Secretary was usually the best business man of the Branch.

The PRESIDENT thought it possible that the Secretary of the Branch might not always be the man who could afford the time and the money to attend the Council meetings. He thought each Branch would know best who was the right man to send to the Council. The Branch secretaries would still have the right to attend the Council meetings if they wished to do so.

MR. RIDDELL agreed with the President. They did not wish the Council to be enormously extended and that was why they had reduced the number of elected members to ten.

MR. ALLBUT also agreed that the present practice as to secretaries attending would, with the altered rules, suffice to keep the Branches well in touch with the Council.

MR. COOK suggested that as the altered rules would not come into force until just prior to the next Annual Meeting, there should be a special resolution empowering the Branches to elect delegates to the Council at once.

MR. RIDDELL'S resolution was carried unanimously, as was also a special resolution proposed by Mr. Cook, and seconded by Mr. Horne, to enable the Branches to elect delegates to the Council for the present year.

Presentation to Mr. Longmuir.

The retiring President (MR. C. JONES), at the request of the President, rose to perform what Mr. Gimson described as a very pleasant ceremony. The Council, Mr. Jones said, felt that in parting with such an able man and member as their friend, Mr. Percy Longmuir, they ought to do something to show their appreciation and esteem, both of Mr. Longmuir and of the manner in which he had filled the office of President. They felt sure that the Association must be the better and the healthier for having had Mr. Longmuir as its President for two years. (Applause). He therefore felt pleasure in being permitted to hand to Mr. Longmuir the address which the Council had had prepared, and which he would ask the Secretary to read.

The address, which was illuminated and framed, was read by MR. ALLBUT. It ran as follows:—

To Mr. Percy Longmuir, M.Met. and Carnegie Medallist.

We, the members of the British Foundrymen's Association, by the presentation of this Address, wish to place on record our high appreciation of your valued services as President, during the two years, 1910 to 1912. Your distinguished position as a practical founder, scientist, and author, have added considerably to the influence of the Association as a purely educative body designed to raise the training and status of those engaged in the founding of metals. As President, you have welcomed large additions to our membership, and impressed all with your high ideals, ability and self-sacrificing work. As the Association grows in numbers and influence, so is its need for wise counsel and personal service increased. For these we rely upon you in the future as in the past.

(Signed) Charles Jones, President.
Sydney H. Gimson, Senior Vice-President.
W. Mayer, Junior Vice-President.
J. E. H. Allbut, Secretary.
F. W. Finch, Treasurer.

MR. LONGMUIR, acknowledging the presentation, said that reference had been made by Mr. Jones to parting. He hoped that there never would be any parting between himself and the British Foundrymen's Association. (Applause). He had had its interests very sincerely at heart, and his greatest regret had been that he could not do more for it. He had not been able to attend Council meetings during the past year, but he hoped when the pressure relaxed to give more time to the work of the Association. (Applause).

The PRESIDENT then delivered his inaugural address, which was as follows:—

Presidential Address.

At this the tenth Annual Meeting of our Association, it is interesting to note our progress. When the first Convention was held, in Manchester, in 1904, there were 98 members, each paying an annual subscription of 7s. 6d. Since then, we have revised the conditions of membership, and we now have seven Hon. Life Members, five Life Members, 192 Members paying £1 1s. per year, 462 Associate Members paying 10s. 6d. per year, and 257 Associates paying 3s. per year—a total of 923, or nearly 10 times as many as we had ten years ago.

This is exceedingly satisfactory progress as far as numbers go, and I am sure that those who note the Papers read at the Branch Meetings and Annual Meetings, together with the keen and well informed discussions which take place, will agree that a valuable increasing work is being done which must very favourably influence the industries in which we are all interested.

We are not, however, content to rest in the position we have reached. We have climbed a certain distance, but there are many peaks ahead of us which give promise of broader outlooks and finer views; they must be surmounted, and the difficulties of the ascent will but add to the joy of achievement. Our Association must become of supreme importance in the foundry trade, so that no live worker in that trade can afford to keep outside. We must help in research work directed towards the solution of the innumerable problems which face us day by day, and we must urge without ceasing the vital importance of the right kind of education for all engaged in the various branches of foundry work.

Your Council is now engaged in an inquiry into the best methods of training apprentices, and an important report should result. The Branches may well influence technical schools and colleges in their neighbourhood to provide classes which will be of real use to youths in foundries.

In the admirable address which Mr. Buchanan—our distinguished first President—gave at the first Annual Meeting, at Manchester, the following sentence occurs:—"I invite my fellow foundrymen to a study of processes bearing upon their life work, a study which fascinates and makes captive all who enter even a short distance within its portals." I felt that I should like to make that idea the text of the larger part of the short address which I am giving to you to-day, for I feel the enormous importance of finding pleasure and happiness in our daily work. We give a great deal of essential attention to processes, methods and products. We discuss pig-iron, steel, non-ferrous alloys and castings of all sorts and sizes. All this is of the first importance, for we are out to make good castings under commercial conditions; our existence as foundrymen depends on the quality and quantity of the work produced.

Just for a few minutes this morning I want to consider the effect of all this work on the men who devote their lives to it. The effect of any trade, or any process in a trade, on the physique and character of the men engaged in it is of greater importance than the value of the goods produced. At least, that is a good general rule. There may be a few exceptions where the value, to society generally, of a product is so great, that some individuals must be sacrificed in its production.

I rejoice to think that out of such a test the foundry trade would emerge with the best of characters. Monotony and lack of interest in work are responsible for deterioration of intelligence and lessening flexibility in the worker. When a man has to perform some small operation, such as polishing the edges of the soles of boots and shoes, day after day, month after month, year after year, with unfailing regularity and monotony, there must result a deadening of his mental activity. His only hope of escaping deterioration lies in making good use of his time of leisure, cultivating his mind and storing up knowledge and ideas which will provide food for thought during the monotonous hours when he is at work.

Often, however, he is too physically tired to do anything better than just find the easiest, and sometimes the stupidest, pleasures to pass the leisure hours and take his mind off his work. Something is wrong so long as a man hates going to work in the morning, and longs to hear the "stop work" bell or hooter in the evening. While appreciating the change of the free hours, it is good for us also that the work we have to do when in harness should really interest us and make us stronger in mind and body. Give a man a problem to tackle, a bit of interesting skilled work to do, and then, providing he is competent, he will find fun in his work, and the hours as they pass will be a real jolly time. Interest in work is the greatest motive force insuring both quality and quantity of result. Those of us who have boys and girls know that, in their school studies, if they are not interested in a subject nothing on earth can make them really proficient in it; but once arouse their interest and they will advance in knowledge of that subject right up to the limits of their capacity. The same is true through life—we are only grown-up children—and it is a natural and inevitable thing that if our occupation is interesting to us we shall do our best work and shall ourselves become more complete, more competent and all round efficient men. The effect is seen outside the workshop, and an interesting industry, calling for brain and skill, makes men and women of greater social value, more interesting companions, good company and good citizens.

Now for a few minutes consider our work. I think there are few industries, if any, which are more important and more interesting, or which make a greater call on all man's mental and physical powers than the foundry trade. I have heard it said that foundrymen are rather looked down upon. If that is so it is only a result of some stupid unthinking prejudice, for no trade with so many problems and difficulties to face, so many interesting and exciting things constantly happening could help producing men of character in all its branches from the highest to the lowest. One hears of men finding England dull and going off into the wilds of Africa to shoot big game for pleasure and excitement. For excitement I think it would not be easy to beat the few minutes when a large and important casting is being poured, and a score of pleasant or unpleasant things may happen. I think on some occasions when I have watched the operation of pouring metal into a large, intricate, and somewhat experimental mould, I have felt as much excitement, and my heart has beat as fast as would have been the case if I were trying to "pot" a tiger from the back of an elephant. At similar times, too, I have seen splendid examples of courage, equal to anything that could be seen anywhere when the molten metal in the runners became seriously disturbed, and fountains began to play, showing something wrong in the mould—the extent of which could not be known—and the men have kept on

pouring, or, if driven away for a few seconds, have returned at the first possibility, and perhaps saved the casting. That is seen frequently in all foundries, and shows real bravery, all the more genuine because it is done in cool blood and not in the rage of battle.

What beautiful skilled work it is to make a complicated mould. William Morris, the poet and artist, used to tell us that beauty in anything made by the hands of man was the expression of the joy of the maker in his task. It is so with good moulding—the moulder may have nothing to do with the design of the casting, but if he loves his work he will turn out a casting with beautiful surface texture, true curves and flats, and with all the problems that face him, such as setting of cores, venting, weighting, etc., etc., so tackled and solved that, as far as his part of the work is concerned, a sound, good, casting is ensured.

If we think of but a few of the problems that face us every day, and those which are dealt with in Papers read before members of our Association, we shall see that we have enough work to keep us always interested and alive, that there is not much fear of things getting too monotonous.

The commercial man will have enough to keep him stirring in the study of costs and selling prices, the proportion of wasters, etc., etc., and from time to time there will be enlivening conversations between him and the foundry manager or foreman. Then the manager and foreman have plenty to think about in producing castings to suit customers or their own machine shop. How to ensure just the right hardness or softness, strength or surface. I can see visions of experiments and discussions extending into the far future on questions such as grading pig-iron by fracture or analysis, quality of coke and sand, cupola difficulties, pressure and volume of blast, casting temperature, shrinkage, physical tests, methods of pattern-making and moulding, the sins of drawing-office designs, etc., Work in a foundry means constant adventures, such a small thing neglected or not known may cause disaster. There is none of the certainty of result that follows in many industries. The work of our Association and others is clearing the way and, by increasing knowledge, making surer results in many directions; but we do not know everything yet, and I hope we never shall, or this old world will be a dull place to live in. Always learning, and year by year doing a little better than before, forgetting some things and perhaps having to pick them up again with difficulty, all adds to the diversity and value and interest of our work. I like to think that our industry never can become monotonous. I know that in some branches of machine moulding and core-making there is a certain danger, but I believe that with care that work also can be made interesting. It is of the utmost importance that we should give attention to this. Already in some industries which have become dull and deadening there is difficulty in getting apprentices. Division of labour is an excellent thing—civilisation has grown from it—but if division of labour is carried so far as to degrade the intelligence of the labourer, then civilisation might well be killed by it.

Let us rejoice that we belong to an industry with multifold aspects calling for our utmost exertion of brain and skill and muscle. Let us remember that while man makes work, work makes the man, and that the end and aim of all work is the happiness and the physical and mental fitness of men and women.

Mr. Longmuir, in proposing a vote of thanks to the President for his Address, said that Mr. Gimson had dealt most ably with the subject of knowledge as applied to the foundry industry. (Applause).

Mr. Cook seconded the motion, and congratulated the President upon the way in which he had brought before them the social problems of the foundry world. The address would inspire them to look at things in a new light, and thus would add zest and pleasure to their work.

The motion was cordially adopted, and the President briefly replied.

This concluded the business of the Annual Meeting.

Members Attending.

The following members and visitors attended the meetings:—

Mr. S. A. Gimson (Senior Vice-President and President-elect); Mr. W. Mayer (Levenbank Foundry, Dumbarton) (Junior Vice-President); Messrs. R. Buchanan, F.R.S.A. (Birmingham), H. Pilkington, M.Inst.C.E., M.I.M.E. (Chesterfield), F. J. Cook (Birmingham), and Percy Longmuir, M. Met. Carnegie Medallist (Sheffield), Past Presidents; Messrs. W. F. Bagnall (Sheffield), J. Ellis (Luton), T. H. Firth (Sheffield), G. B. Henderson (Southampton), C. Heggie (Birmingham), H. Jewson, J. Oswald, M.Inst.Mech.E. (London), T. Macfarlane (Horsehay), H. Pemberton (Midland Railway Company, Derby), M. Riddell (Falkirk), T. Swinden, B.Met. (Sheffield), and J. Smith (South Shields), Members of Council; Mr. F. W. Finch (Gloucester), (Hon Treasurer); Mr. J. E. H. Allbut (Manchester), (Secretary); Mons. E. Ronceray (Treasurer), and Mons. Delalande, representing the French Foundrymen's Association; and Messrs. J. W. Horne, B.Sc., Assoc.Inst.C.E., T. Murphy, E. A. Pilkington (Sheepbridge), W. Barningham, H. Winterton (Birmingham), J. Matthews (Walsall), W. Jones (Blaenavon, Mon.), J. Ledgard (Low Moor), Jas. Stewart (Manchester), B. Doulton (Glasgow), A. J. Bird (Guernsey), F. J. Cree (Earl's Colne), B. Sperring (Portsmouth), W. A. Young (London), E. Smith (South Shields), E. H. Broughall (Coventry), J. Wharton (Maryport), T. W. Aitken (Luton), F. Blackwell (Luton), A. Leidig (Manchester), J. Feasey (Leicester), J. Bowman (Lincoln), H. Mather (Birmingham), A. P. Bartlett (Belvedere), J. G. Dobson (Birmingham), J. Meek (Ipswich), S. H. Russell (Leicester), A. S. Kay (Stoke-on-Trent), A. Bowman (Burnham-on-Crouch), W. H. Freeman (Misterton, Gainsborough), P. Fox-Allin (Birmingham), G. M. Mather (Ashford), M. E. Gallon (Dunston-on-Tyne), M. B. Herbert (South Shields), W. Rawlinson (Bolton), W. C. Prestwich (Dronfield), J. Tattersall (Birmingham), W. J. Boyle (Bonnybridge), H. F. Jackson (Exeter), C. Mace (Birmingham), J. King (Oldham), R. Shaw (Failsworth), J. Hassall (Sheffield), J. Herfoot, A. Walker (Glasgow), J. Batch (London), G. Edginton (Chesterfield), A. Fontaine (Newport), H. Griffiths (Cardiff), J. N. Simm (Gateshead), T. B. Gillies (London), A. Hayes (London), G. H. Stamp (Birmingham), A. Sutcliffe (Radcliffe), H. B. Johnson (Manchester), J. Nicholls (Manchester), R. H. Pickles (Mytholmroyd), W. Evans (Falkirk), J. E. Sellars (Manchester), H. Grandidge (Manchester), W. Henderson (Manchester), J. W. Worrall (Luton), B. J. Fletcher (Leicester), H. Loxton (Leeds), J. B. Howard (Colchester), W. Gower (Blackburn), R. Carrick (Shipley), E. Kilburn Scott (London), E. W. Murphy (London), C. H. Ivinson (Ilford), W. Wright (Falkirk), T. Baugh (Birmingham), W. Douglas (Newcastle-on-Tyne), C. Hilton (Luton), T. Campbell (Larbert), and J. B. Durran (Sheffield).

Papers and Discussions.

The PRESIDENT, before calling upon Mr. Riddell to read his Paper, remarked that it was obvious that their arrangements were not quite satisfactory. They really ought to allow longer time for the business meeting. Half an hour was the time allotted, and an hour and a quarter had been occupied. He thought they ought to have a three days' Convention so that they could give up one morning to the business and the other two to the Papers. (Hear, hear.)

Semi-Steel.

MR. M. RIDDELL (Falkirk) then, with the aid of lantern slides, gave a *resumé* of his Paper on "Semi-Steel." This Paper appears on another page of this issue.

The PRESIDENT said that the Paper was very interesting. He could not himself open the discussion as he had not made any special study of the subject, but he realised that Mr. Riddell had given them very many useful facts and hints.

MR. F. J. COOK said that Mr. Riddell's Paper was intensely practical, and that, of course, added a good deal to its value. One feature of the Paper was the glory given to American founders for taking such a deep interest in the question of semi-steel, and perhaps between the lines, the condemnation of Englishmen for not doing the same thing. That sort of thing was very often levelled at the head of the average English foundryman, the suggestion that he did not take an interest in physics, heat treatment, pyrometry, and so on, and therefore did not reach the perfection that was reached in America. He (Mr. Cook) took every opportunity of resenting that accusation. Necessity was the mother of invention, and everybody who knew the difference between American and English irons knew the reason for the great interest taken by the American foundrymen in these matters. Those things were not required in this country, because some British irons would give better results than American irons, even after all this doctoring. He was greatly interested in the physical properties of iron and did not fail to notice anything concerning that coming from the other side of the water, but he had never seen any results obtained in America with this doctoring which could not be equalled and even surpassed in this country. Semi-steel was not needed in this country to improve the strength of cast irons, whether transverse or tensile strength. In fact, adding steel to some good English iron did not increase the tensile strength, but rather decreased it. He had had many years experience with steel additions, so that he had no prejudice against steel in itself. But his experience was that though one could improve a bad iron, one could not improve a good iron. With a low-silicon iron having something like 3.25 per cent. total carbon, he got excellent tensile strength with 500 daily tests, and adding steel to that iron only brought the tensile strength down. A mixture of steel did add other properties which were very essential; for instance, it tended to increase the wearing properties. That was due, he thought, to the fact that when steel was added to cast iron the ferrite was in some different condition, though he was not prepared to say exactly what that condition was. When ordinary cast iron intended for machine work was examined under a high-power microscope there were seen to be little needles left standing on the surface. These were more brittle if steel had been added, and these under a scouring action formed a coating which increased the wearing properties. Therefore, for increasing the wearing properties of irons, especially those which were to be used in high temperatures, the addition of steel was a good thing, but he must repudiate the idea that it was necessary for increasing the strength of English iron; the strength could be got without that doctoring. The author had spoken of alterations in the chemical analysis. In that, he (Mr. Cook) must support the author very strongly. The cementation would vary; the products of the addition of the steel were not chemically exactly what one would expect them to be. The chemical analysis of steel with iron showed that the carbon was frequently very little reduced. In one special iron, with not more than 3.25 per cent. total carbon the greatest reduction was to 3.08 per cent. It seemed quite possible that this high carbon was due to cementation, but the fact remained that they could not by adding steel reduce the total carbon below that point. Another very interesting fact had come to his knowledge. For some hundreds of analyses the total carbon had never been below 3 per cent., either with semi-steel, or anything else. He was only giving this from practical experience and not as a scientific fact. He could not go so far as the author of the Paper in saying that high-carbon steels were the best to mix with cast iron. One of the first warnings he ever had with regard to semi-steel was from an old practical man who had used it for very many years. The warning was, "Don't use files." He (Mr. Cook) did not know why, seeing that files were thin, and gave the greatest surface to work upon, and had high carbon. But he must say that after about two experiments he put in no more file steels. The result was not so good as when using mild steel, with which he had had no difficulty. The very mild steels gave the best results. He would like to know whether the author could tell them anything about that. He (Mr. Cook) knew from practical experience that very high carbon steels were bad things to add. With regard to shrinkage and sinking, he had only used this metal for very plain articles, but he had always felt that the metal was dangerous to use for very complicated castings, owing to the possibility of sinking and shrinkage. The iron he used had 1.5 per cent. silicon, and not more than 3.25 per cent. total carbon, which was reduced to 3.06 per cent. by the addition of 18 per cent. of steel. With regard to hard spots and blowholes, to which the author had referred, it was suggested in the Paper that they were due to bad mixing. He (Mr. Cook) did not think that was right. The cause was not insufficient stirring but melting at too low a temperature. It melted high enough the metals would mix themselves, and the spots and blowholes would not occur. In conclusion, Mr. Cook said he considered it was a very good procedure to allow the steel to soak in the cupola before melting.

MR. CARRICK (Shipley) said that they were greatly indebted to Mr. Riddell for having introduced this Paper and for having dealt with the subject (which was in a state of embryo, in this country, at any rate) in such an able manner. His theory regarding the absorption of carbon was no doubt the correct one, and no greater proof of that need be mentioned than carburising for case-hardening, where from 0.75 up to 1 per cent. carbon was frequently absorbed. Mr. Cook had said that he had never come across a case of semi-steel having less than 3 per cent. total carbon. He (Mr. Carrick) held in his hand an analysis of semi-steel made within the past two months that gave only 2.87 per cent. of total carbon, with about 1.97 per cent. of silicon. He had had some little experience in the making of semi-steel, his first experience going back

some five years ago, when his firm bought a pig-breaking machine. It had not been working more than three weeks when the eccentric crusher casting used in breaking the pigs broke off in large chunks. The pattern was sent for and another casting was made containing 25 per cent. of mild steel. That casting was still working and showed very little signs of wear. That clearly proved that there was a field of usefulness for semi-steel. One of the remarkable features in Mr. Riddell's Paper was that whilst the transverse tests were exceptionally high (one case mentioned being 4,800 lbs. or 1-in. sq. bar) the tensile tests were not very high, 15 tons only being recorded on the same metal that had given the high transverse test. He (Mr. Carrick) had noted the same thing in his own tests. This was a matter that needed careful research and attention, and it was hoped some explanation would soon be given. Mr. Riddell had spoken about hard spots but had not given them any idea about the general hardness of his metal. Had the author made any hardness tests? His own experience had been that the semi-steel was much harder than an ordinary cast iron containing, say, 2 or 2.25 silicon. The tests he had made with the Brinell hardness tester gave an indent of 3.5 millimetres with 3,000 kilos. pressure, whereas the indent on ordinary cast iron was 4.2 to 4.5 millimetres with the same pressure. This was a very serious item where there was a lot of machinery and where expensive cutters were used. Like Mr. Cook, he had always used the low-carbon steel for his semi-steel mixtures, being under the impression that it was not advisable to use files and high-carbon steel. Mr. Riddell had advised the use of high-carbon steel to prevent blowholes. Would he kindly explain his theory? He (Mr. Carrick) referred to a pamphlet on semi-steel, in which was recommended the use of high manganese. Mr. Carrick quoted a sentence from the pamphlet, which said that "manganese raised the saturation point of iron for carbon." Would Mr. Riddell kindly give them his experience on this point. In conclusion, Mr. Carrick asked Mr. Riddell, in his reply to the discussion, to kindly give more particulars regarding his method of charging, etc.

Mr. Jewson asked Mr. Riddell to give them details of his experiments with regard to blowholes. Were the steel spindles identical in size and were they polished? Was there any oxide on them?

Mr. Riddell: They were all polished bright and all of the same size.

Mr. J. Smith said that he had been delighted to hear Mr. Riddell's Paper. He himself had had considerable experience of semi-steel mixtures, and he found that, as was said in the Paper, the heating of the metal had a great deal to do with the results. He at one time was putting in 30 cwt. charges, and he found that by using from 10 to 15 cwt. he could not get the same results as with 30 cwt. charges. He had noticed on several occasions when tapping the furnace that the steel came out in clots. By increasing the charges and using the same quantity of coke, very much better results were got. But the great difficulty with semi-steel mixtures was in pouring the heavy castings. If they were not fed very slowly and kept open for a very long time there were sure to be hollow places in the casting. On castings of smaller thickness the results were very different. Apart from ordinary troubles, he thought that the bad results got from steel mixtures were due to the fact that the furnace was not kept up and the iron melted as it ought to be. Mr. Cook had said that steel did not improve the strength.

Mr. Cook: What I said was that it does not improve good iron, but you do improve bad iron by adding steel.

Mr. Smith said that he had in use a mixture which he had used hundreds of times, and his experience was that steel did improve the strength of iron But the proper strength with semi-steel mixtures could not be got unless the furnace was hot; the high melting was the secret of success.

Mons. Ronceray (Treasurer of the French Foundrymen's Association), who was called upon by the President, made a few remarks on the Paper, discussing principally the reduction of silicon by steel additions. He also pointed out that while sulphur could be taken up to some extent from the coke, manganese could not be absorbed in the cupola.

The President, owing to the shortage of time, requested further discussion to be handed in to the Secretary in writing.

Mr. Riddell, in his reply, thanked the members for the way in which they had received his Paper and for the very valuable information that had been given him in the course of the discussion. He had not intended at all to elevate the Americans at the expense of his own countrymen. He had referred to different ironworks to show that work with semi-steel could be done regularly and with commercial success. He did not quite follow Mr. Cook as to not improving good iron. He did maintain that steel would strengthen a weak iron. The table at the end of the Paper would show that the hematite and other mixtures increased the tensile strength more successfully with the steel than without it. He had no doubt that the needles or spicules spoken of by Mr. Cook were broken down smaller in the case of semi-steel and that this tended to increase the wearing properties. To increase the melting point in the cupola certainly strengthened the iron. If with semi-steel mixtures a little more coke was used to get absolutely reliable results, there was a gain by being able to reduce the sections, and so the weight of castings. The adoption of semi-steel would also increase the probability of cast iron being very much more largely used for engineering and mechanical purposes, and thus should benefit the foundry industry considerably. In reply to Mons. Ronceray, he would say that the silicon was reduced by the introduction of steel. As to the Americans needing to add steel because of the badness of their iron, the point of his Paper, which he was sorry had been neglected, was to show generally the practicability and commercial possibilities of semi-steel mixtures. In reply to the suggestion as to manganese, he did not think they gained anything by adding manganese to semi-steel mixtures, unless for those purposes for which it would in any case have been added.

Brass Quantity Pressure in Cupola Working.

Mr. Cook, in introducing this Paper, by a brief resumé of its contents, pointed out that to check whether any particular cupola was working up to its maximum capacity did not require a set of apparatus as described. If the cupola was worked for a short time under the conditions given in the Paper, and the result in tons per hour was multiplied by 120 and divided by the diameter of the cupola at the melting zone in feet, it would give a quotient of 330 if the cupola was working at its full output. A figure less than 300 meant that more air was required—unless (which could easily be seen) too much air was already being supplied and oxidation was taking place.

The SECRETARY (Mr. Ahbut) read two communications upon Mr. Cook's Paper which he had received.

PROFESSOR T. TURNER wrote:—I have read the Paper on "Blast Quantity and Pressure in Cupola Working," and congratulate the author on the results obtained. I fear I cannot speak with any authority on this subject, as I have never conducted any experimental tests of the kind described. The only thing that strikes me is that pressure and volume (or weight) of air are only other ways of expressing quantity, and perhaps distribution. These should have counterparts in the silicon removed, and in the composition of the waste gases. The cold charges, with excess of air, probably mean the cooling effect of nitrogen, and a deficiency in the gases.

PROFESSOR J. GERMIAN PORTER (late of Cincinnati University, U.S.A.) wrote:—"It is indeed a pleasure to read the results of a research so admirably planned and so lucidly described. The subject is of the very greatest practical importance, and Mr. Cook is to be congratulated at having apparently gotten to the bottom of it. It is a new idea to me that pressure is a factor affecting the rate of melting aside from its influence on the quantity of air entering the cupola. Mr. Cook, however, has adequately proven the fact, and it is not difficult to find a theory to fit the case. Assuming a fixed ratio of fuel to iron, the rate of melting will depend upon the rate at which the fuel is burned. Assuming a fixed rate of blowing, the rate at which the fuel is burned will depend upon the way in which it is burned, *i.e.*, upon the proportion which is burned to carbon monoxide and the proportion burned to carbon-dioxide. Twice as much air is required to burn a pound of fuel to carbon-dioxide as to burn the same weight to carbon monoxide, or, putting the facts in a different way, with a given rate of blowing, twice as much fuel will be burned per unit time if carbon monoxide only is produced; and assuming that the ratio of fuel to iron is constant, the rate of melting will also in this case be twice as great. I have shown in the Paper cited by Mr. Cook that the proportion of carbon monoxide formed is roughly dependent upon the rate of blowing. It is, however, not only possible but also highly probable that the pressure of the air entering the cupola is also an important factor influencing the products of combustion, and it seems that it must be in this way that blast pressure has so great an effect on the rate of melting."

"It is unfortunate that circumstances did not permit Mr. Cook to have analyses of the top gases made during his experiments. These additional data would have enabled us to follow the combined influence of rate of blowing and pressure on the chemistry of combustion. To study the influence of pressure alone would require a separate experiment with an especially designed cupola and blower."

"It is proper to point out that since Mr. Cook's formula for rate of melting is based only on quantity and pressure of air, it will hold only for the particular fuel ratio used in his experiments."

"The most valuable and interesting of the conclusions given is, in my judgment, the formula for the maximum possible rate of melting. On both sides of the water foundrymen have long realised that pressure was an important factor, and that with too much pressure, as well as with too great a volume of air, oxidation troubles and bad castings resulted. It has remained, however, for Mr. Cook to definitely formulate these facts and to give us practical limits by which we can work. His data, if properly used, should be of inestimable practical value to the foundry industry."

MR. GALLON (Dunston-on-Tyne) said that looking over the formulæ given in the Paper, he found them, from a scientific standpoint, *par excellence*, but science could not always be applied in practice. For instance, what was the use of talking to him about producing four or six tons of iron out of the cupola when he had only a 2-ton blower. He could not get the amount of blast to produce the iron. Therefore, so far as that part of the Paper was concerned, commercially it was not sound. Mr. Cook had put great stress upon the weight of air. As a practical foundryman, he would ask, had they time to weigh the air when starting to blow? Therefore he would say, that too much confidence should not be placed in Mr. Cook's formulæ. These could not be followed very closely; but the amount of air or the number of cubic feet of air being used could be followed, and that was all. When starting the blast, the number of revolutions of the fan or blower was known; it would give a certain number of cubic feet. That was all that could be done in practice. Therefore, while it was desirable to know that a certain amount of air in weight would produce a certain amount of iron it was more desirable to know how many cubic feet of air would produce a certain amount of iron. That, in his opinion, as a practical man, was the only way the blast could be regulated when it had once been started. He had done a bit of experimental work himself, and found that Mr. Cook and he had been working cupolas of practically one size. He got pretty much the same results as Mr. Cook did in ratio. He might also remark, that Mr. Cook in his experiments, had got a "flying start" every time. (Laugnter.) "Flying starts" were not got in practice. The foundryman melted from the time he began to blow and went on all day until the time he finished, and counted from the time he started until the time he finished, the amount of work done. But to start half-an-hour after the furnace began to blow was not a commercial test. All who had experimented with the cupola knew that the best work could be got half an hour after the cupola had started, when it was in full swing, as it were. Another point was that when they had 15 ozs. of pressure, there was oxidation of the metal caused by the extra pressure of the blast. He believed that it probably came about by the cupola hanging for half a minute or a minute and the bed charge getting too low. Thus the cold blast struck upon the iron and oxidised it. He believed that if the cupola were properly worked from the start to the finish and sufficient coke were used to start with, it did not matter what amount of blast were used. If the melting zone were kept at a proper height, there would be no loss from the oxidation of the metal through air blowing onto it. Regarding the other part of the Paper, that was "B," it was shown that with 15 ozs. of pressure there was no oxidation of metal. If it were got in one part it should be got in another, but up to 15 or 16 ozs. of pressure there was no oxidation until 10 tons of iron was arrived at, and then there was oxidation. He (the speaker, thought that in both cases the charge had got too low, and that had caused the loss of iron in the cupola.

MR. PEMBERTON said that from the results given in the Paper, it was obvious that some definite data were to be obtained therefrom, but the usefulness of those data was just how far they affected different cupolas. Mr. Cook spoke about 0.09 lbs. of coke with 90 per cent. carbon as being the correct amount of coke for a high phosphoric iron. He (the speaker) thought Mr. Cook was using a lot more coke than was necessary for that class of iron. Nor did he mention in his Paper any physical properties of coke. These should be given in conjunction with the chemical analysis of the material being used. He (the speaker) had done a

little work with regard to the physical properties of coke, and cupola work, and found that 0.055 lbs. was quite sufficient, when using pig-iron and charging up with 50 per cent. of ordinary No. 1, 2, 3 or 4 grades of common pig-iron. At 50 per cent. and up to 80 per cent. of common pig, 0.065 lb. of coke per lb. of iron melted was required, but when hematite pig was used, up to 50 per cent., 0.075 lb. of coke was required. With 50 per cent. to 80 per cent. of hematite, 0.0875 lb. of coke was required; whilst with 50 per cent. of hematite, somewhat nearer to Mr. Cook's figures, only 0.075 lb. of coke would be required per lb. melted. They found that they were using 10 cwts., which gave 1,138,000 B.T.U., with an advance of pressure to 13.5 in. of water. That coke, he might say, had a greater density than water and sank. If coke, which floated with a quarter of its bulk out of the water, were used, it would be necessary in order to get efficient working of the cupola, to reduce the pressure to 9 in. of water: he meant on a test run over a whole day and not just a run of one hour, or half an hour. He was rather inclined to think that Mr. Cook's tests of half-an-hour or one hour respectively were hardly long enough to give them anything very definite. If they used a coke which floated with 75 per cent. of its bulk out of water, the blast pressure had to be reduced to 6 in. of water, thus showing that there was a great deal to be said with regard to the physical properties of coke. There was another point concerning chemical analysis and blast pressures. Now on this the quantity of air for combustion depended. If the proportions of air and carbon were not fixed and one or the other were varied, a different atmosphere was bound to follow in the cupola itself, with corresponding effect upon the constituents of the cast iron. The Paper would give them the idea that the whole question was one of output of iron in the foundry, and no mention was made of the influence of the various constituents of the cast iron on its properties. It would appear from the Paper that these played a very minor part in relation to the properties of cast iron, and that volume and pressure were the dominating factors.

He had a couple of questions for Mr. Cook. If a fixed ratio of air and fuel was the case, and since it was admitted that pressure had a decided effect upon the strength of cast iron, would it become necessary to change the area of the tuyeres and also their number, and this during a day's run upon miscellaneous work? That brought up another question—what was the true relationship, and on what should that relationship be based, being tuyere area and diameter of cupola (or area), and did the disposition have any effect upon the constituents of the iron with regard to blast pressures?

Mr. Riley observed that Mr. Cook had raised objection to the use of No. 2 and No. 3 methods of measuring air, and had expressed a preference for No. 4. His own experience had forced him to prefer No. 1 method. His objections to the use of No. 4 method were:—(1) The cost of fitting a Venturi meter to an existing range of piping; (2) the inaccuracy due to the loss of energy, which amounted to about 5 per cent. in well-designed meters for water measurement. Losses were got due to what was known as eddy motion, due to the roughness of the Venturi tube. That could be overcome by polishing the inside of the meter. The method that he (the speaker) preferred was No. 1, *i.e.*, the Pitot tube. He had met with the same difficulty that Mr. Cook had, same depression of the liquid levels in the meter. In one case, where 3,000 cub-ft. of air were being sent through a 14-in. pipe, the deflection was on ⅛ in. That was obviously too small for reliable work. The method the speaker adopted was to use an inclined U-tube slightly tilted with a liquid of lower specific gravity than that of water. By that means a depression of any amount could be obtained, depending on the specific gravity and the inclination. He saw no difficulty in using in every-day practice the velocity gauge with the pressure gauge. A velocity gauge could be bought for 10s., and would give pressure and quantity passing through the cupola per minute. A velocity gauge could be easily made out of two tubes constructed of the ordinary lubricating pipe used on engines, attached to a horizontal U-tube.

Mr. F. J. Cook, replying to the discussion aroused by his Paper, observed that he had had hopes of a good discussion, and he did not think they had failed to get it. The same remarks had been made by Professor Porter and Professor Turner with regard to the composition of the gases given off. He (the speaker) had the idea in mind at the time, but unfortunately he had not the use of a laboratory at the works. If analyses had been taken, no doubt very valuable results would have been obtained. Mr. Gallon did not consider that the Paper had any value from a practical point of view, but he hoped that after he had looked into it a little further he might be able to alter his opinion, because the results mentioned had been obtained from practical working, and as far as possible the experiments had been made on very definite lines. Mr. Gallon had objected to some of the methods by which they had been taken, but it was absolutely necessary to make experiments under known conditions, to get reliable results. Those experiments were not the only ones. They had been going on for years, and the results had been taken over a whole day's blowing as well as over short periods. There was apt to be many variations in working under ordinary practice, such as the opening of the slag hole, and so on. If they were going to make all those allowances the results were not nearly so valuable as knowing what they could do in a very short period. The first point raised by Mr. Gallon was that he had a 4-ton cupola and only a 2-ton blower. No data he (the speaker) could give Mr. Gallon would enable him to turn a 2-ton blower into a 4-ton one. Mr. Gallon could not blame the Paper for not helping him in that direction; he ought to get a blower of ample size (a Voice, "and engine"). That went with it, of course. As practical foundrymen they knew that if they were to get the best results from the cupola they must have appliances such as they could use to the best advantage and he contended that any cupola should be supplied with a blower that was ample for the work it had to do, and one that could be varied at will. That could easily be got over in these days of electricity by using a variable-speed motor attached to the blower. There were, they knew, practical difficulties in the way, but foundrymen would be repaid if they insisted on it when a new plant was being installed. He noticed that Mr. Gallon still stuck to "feet of air" instead of lbs., but he thought he had dealt with that in the Paper. A foot of air to-day was not the same as a foot of air to-morrow, for practical purposes or a cupola. It did not contain the same amount of oxygen, and could not be the same kind of air, whilst the percentages of oxygen varied. For instance, during the whole range of the tests the difference in the amounts of oxygen between extremes had been 19 per cent., so that the man who measured the air by cubic feet might be 19 per cent. worse off one day than another, without knowing it. He could not be if he took the weight of air. The results were taken for periods of 2½ mins.

over a whole afternoon's work, and so it did not take long to take a record. Mr. Gallon said he did not believe that the oxidation was due to excessive pressure or to excessive volume, and he pointed as a proof to the fact that oxidation was got in a small cupola without heavy air pressure. It was no proof. With 15 oz. of pressure in a small cupola a certain result was got—points of air multipled by the square root of pressure in relation to the diameter of the cupola. If the same conditions obtained in a large cupola the same results were got, and the same oxidation at the same point with the volume of air. He took the same pressure of air coming in and he found that if the cupola was hanging the same oxidation was got. The cupolas were vastly different in diameter and also in tuyere area, and seeing that oxidation was obtained with the same relative proportion of air, he thought it proved that the theory was correct. Mr. Pemberton had raised objection to the 0.09 lbs of coke per lb. of metal melted. That was a figure obtained by Professor Porter. It was not his own figure. Professor Porter's was a very long Paper, and he could not read it, but he would be happy to lend it to Mr. Pemberton. Professor Porter went into the question from a very practical as well as theoretical standpoint, and he thought came to a very sensible level. He knew that Mr. Pemberton got very good results from his coke in melting, but for safe everyday work Professor Porter's was a very reasonable figure. He did not say that they could not get a very little better figure for certain conditions. As a matter of fact, he got one a little better himself. It was, however, less expensive to use up a little more coke than to have bad iron. The physical properties of iron formed a very big subject, which would occupy them for a month, but he wuld try to reply to Mr. Pemberton in the "Proceedings." Mr. Pemberton wanted to known if the tuyeres had to be changed for different conditions. He (the speaker) did not say that would not be a good idea if reasonable facilities were available, but as furnaces were built at present there were not great facilities. But with a variable-speed blower they could vary it as they wished. He had found no difficulty in their own practice, extending over twelve years, in doing that. When they came from ordinary iron to silicon iron they altered the rate of the blower and got a difference in pressure with very good results. A gentleman had raised the question of Pitot tubes in foundry work. In foundry or laboratory work there was no doubt about it, they were obliged to have intensely fine readings with the Venturi tube to get good results. He quite appreciated alll the benefits to be obtained by inclining a manometer connection, but the amount of inclination that could be obtained was not sufficient to give as satisfactory a result as with a Venturi tube. A Venturi tube cost something, of course, and should be polished, and like any other apparatus, had to be properly designed. For that reason he gave in his Paper data for ordinary practical purposes, and he still thought that the method adopted was the best of the lot, because the variation obtained was more easily read than with a Pitot tube.

Artistic Treatment of Cast Iron.

Mr. J. B. Fletcher then gave a resumé of his Paper on "Artistic Treatment of Castings," and illustrated it with a number of interesting slides. A brief discussion followed.

The Convention then adjourned until Tuesday morning, the afternoon being spent in the visits that had been arranged and the evening at the Annual Dinner of the Association, which was held at the Holborn Restaurant.

SECOND DAY'S PROCEEDINGS.

The Alloying of Aluminum.

The first Paper read on Tuesday was that by Mr. C. H. Ivinson (London), on "The Alloying of Aluminium," which appears on another page of this issue.

Mr. A. Hayes (London) said that he had for some considerable time followed aluminium, and he would like to ask Mr. Ivinson whether he had ever come across any material evidence of a phenomenon which he (the speaker) had witnessed—the ultimate physical deterioration or disintegration of aluminium alloys which, when freshly made, exhibited exceptionally good physical properties but which, after a period of perhaps one or two years, showed great deterioration and apparent change in condition, as shown by the fracture. He had come across evidence of something which, at first sight, appeared almost akin to the "tin pest." It was almost a crystalline change in the alloys, if not a chemical one, but it only occurred after a considerable period of time, and in a dry atmosphere. He could not quite account for it by the law of oxidation. He had since seen evidence of similar defects in other alloys, occurring at a very much more rapid rate, and these were not so surprising. One alloy, seen at the National Physical Laboratory, had crumbled to powder in a few months. But that was not a commercial alloy. It appeared to him that in almost all aluminium alloys there might be a liability to disintegration in that form.

Mr. Ivinson replied that the electrolytic action and chemical action of aluminium and its alloys was a very fascinating subject, and a very large one. He believed that the rock bottom of the science of oxidation was electrolytic action. For instance, an alloy of aluminium with 5 per cent. of tin might have at first a tensile strength of, roughly, 10 tons to the sq. in., and in a few weeks' time it might come down to even less than 4 tons. The structure of the alloy when freshly made and studied microscopically gave a close grain, but in a few weeks' time the alloy formed crystals quite different from the original sample, and when it was freshly broken it had a smell of silicon hydride. There was something which, in the presence of water, gave off a gas which absolutely rotted the alloy. It was both electrolytic and chemical action. There was hardly a line to be drawn between the electrolytic action of metals and the chemical action of metals. For instance, titanium, when alloyed with aluminium up to, say, 0.50 per cent., when freshly made, gave a very strong alloy, but in the presence of moisture titanic acid was developed on the surface of the alloy, which rapidly corroded. If one polished a metal containing a certain per cent. of aluminium and placed it in sea water, spots developed on the surface, and when those spots were removed by means of a cloth, deep pit marks running almost through the whole structure of the metal were found. Not only was there that effect, but the crystalline form re-crystallised after about three days. Antimony was very similar. It alloyed with aluminium rather badly; there was not affinity between the elements, which separated into two layers. The bottom layer would rapidly disintegrate in the presence of moisture. His theory of the electrolytic action of metals was that when two dissimilar metals were brought into contact voltaic action would take place at their junction. When any dissimilar metals were brought into intimate contact, a local voltaic current was generated at the junction. Under those conditions, aluminium being very electro-positive, was very easily attacked, especially in liquids and moist air.

Electric Furnaces in Iron and Brass Foundries.

The next Paper, by Mr. E. Kilburn Scott, was on "Electric Furnaces in Iron and Brass Foundries." It was given in abstract with lantern illustrations. The text appears on another page.

Mr. H. Pilkington (Chesterfield) said that he was interested in electric furnaces, and he noted that no mention was made of electric smelting. This, however, was not exactly germane to the question. Mr. Scott had expressed some rather pessimistic views, but the speaker did not think that the average manager took such a pessimistic view of the electric furnaces as Mr. Scott had suggested. The managers simply studied them from a practical commercial point of view, and he (the speaker) had come to the conclusion that pig-iron would continue to be made in blast furnaces for a long time yet. What he was concerned to know was what size of furnace was practically possible at the present time, how much current would be required, and the cost for a given number of tons of metal. He had not the slightest doubt that with regard to purity of melting the electric furnace must be superior to the types at present in use.

Mr. A. Hayes remarked that Mr. Kilburn Scott had shown some bias as to the value of the Hering furnace, but he (Mr. Hayes) appreciated that bias. He had followed the development of that furnace since its inception, and it had struck him at the time as being sufficiently distinct in principle to warrant careful attention. An important feature of its operation was the ebullition of the metal, which was very desirable, and which was not obtained, as far as he was aware, in any other electric furnace. In steel, for example, it was a great advantage in aiding the refining process, which took place at the under surface of the slag, by contact of metal and slag. With most furnaces a rapid circulation of metal was not obtained, whether the furnaces were arc, induction or resistance of the ordinary type. Accordingly the refining process was not very rapid The ebullition characteristic of the Hering furnace appeared to him to be a very important factor, particularly in the melting of metal, because there was in every metal a certain amount of included or occluded matter which required to be removed. This matter was merely mechanically suspended and the circulation in the furnace was bound to aid in removing it. As bear this out he might mention that one iron foundry in America had installed one of these Hering furnaces to overcome trouble with cylinder mixtures. The metal was melted in a cupola and tapped direct into a furnace of the kind described by Mr. Scott and kept there for ten or twenty minutes, after which time quite a quantity of undesirable matter was skimmed from the top of the metal as dirt. This was simply the result of the ebullition releasing the dirt or undesirable matter. Since then they had had no trouble from the same cause, and they found that the saving in waste of the metal quite compensated them for the total outlay. He thought that Mr. Scott had not stressed as he might have done the application of this furnace in the iron foundry. He himself went so far as to fly in the face of some statements made by some American and Continental steelmakers as to how far the electric furnace was applicable in the iron foundry. The fact was that the power question so prejudiced the average contemplating user that he would not go into it: such a man said "High power consumption" and thought that settled the matter. But one must not take the furnace alone. The total overhead charges of a plant equipped for the work should be considered. For certain special classes of iron-foundry work it would be found that the reduction of overhead charges would in some cases more than compensate for the extra cost of the electric furnace; he included in these overhead charges the reduction in the number of wasters, the number of boxes, the amount of handling, the floor-space required, the capacity of building to accommodate the moulding, the handling of the metal, the crane capacity, the cost of the cupolas, and their general equipment. In fact, the whole total equipment of plant must be included in the overhead charges. In comparing a plant properly constructed for electric-furnace practice with that of the present furnace plant, they would, for some classes of work, find the balance in favour of the electric. When they came to brass work they would find a very much greater margin in favour of the electric furnace, because such an immense amount of trouble and waste resulted from oxidation. He did not think one could rub that in too much. The possibilities as to brass and bronzes were absolutely immense, but they were very much restricted at the present moment by the fact that no efficient melting furnace had been designed for the general class of work. Discussing the subject with Dr. Hering himself, he (Mr. Hayes) had raised the question as to whether the furnace mentioned in the Paper was efficient for melting electrolytic copper, suggesting that the efficiency of the furnace might be very low, by reason of the resistance to the passage of current being very low. Dr. Hering said that he had faced that problem, and had constructed a special furnace and had got excellent results. This would give them an idea of the immense possibilities of the electric furnace for brass work. (Applause).

Mr. Swinden said that he had several times visited the Trollhätten works where pig-iron was being regularly made with the electric furnace. One point that struck him was Mr. Scott's assurance that the electric furnace would do exactly what it was told to do. His own experience of electrical apparatus had always been that it would not do that. With regard to the ebullition of the metal, which was claimed as a great advantage, he had seen several electric furnaces, and it was the quietness of the metal that had always struck him as an advantage of such furnace, as it allowed a "quiet" finishing in the refining, which was considered highly desirable. In the case of the Hering furnace, he thought that some of that advantage would be lost. In the other furnaces the metal, at the end refining, could be seen lying perfectly still. He thought that a great feature of the electric furnace was its quietness. There was no doubt, as Mr. Kilburn Scott had said, that the electric furnace had come to stay, and that there was a great future before it, but the biggest problem for the manufacturer was not the type of furnace. There were several furnaces available which would do the work, it was more a question of getting a market for the material. There was a pretty good range at present for the different classes of steel-making, the Bessemer furnace, the open-hearth, crucible, etc., and it was rather difficult to say exactly where the advantage of the electric furnace for steel-making came in from the commercial point of view. It was not altogether sufficient to say that the cost was no more from a manufacturer's point of view; he had got to experiment and he could see no advantage in it unless it was certain that the electric furnace would give him better commercial results.

Mr. Freeman said that he was employed in a foundry in a village. Hence they had not electric power handy. Therefore he did not expect to find the electric furnace a practical proposition for him just yet. There was some contradiction between the views expressed by different speakers. Mr. Scott

had told them it would pay to put in an electric furnace to melt iron or brass, whilst another speaker said it would not pay for ordinary general foundry work. He would like to ask whether anyone had put in an electric furnace for such work in this country with satisfactory results?

MR. SCOTT: No! They have not started yet.

MR. HORNE said that at the invitation of Mr. Kilburn Scott he had visited the Northampton Institute, and had seen a practical demonstration, certain data as to which he had taken, but was not in a position to discuss. There was no question, to his mind, that in the Hering furnace melters of alloys would get something for which they had been waiting for years. The metal he saw used in the furnace was certainly only lead, but he might say that 120 lbs. were melted in 21 minutes, starting up from the cold solid metal. The great advantage was that in the electric furnace the oxidation of non-ferrous metals was reduced to a minimum. He could foresee developments in that furnace which would ensure there being no oxidation whatever, and that, they would agree, would be a very considerable advantage. (Hear, hear.) Another great possibility in this furnace was in smelting, or rather, reducing the oxides of metals having volatile metallic constituents. It appeared to him quite possible to construct the furnace in such a way that the difficulties arising from volatilisation would be avoided.

MR. KILBURN SCOTT, in his reply, referred first to the application of electric power to blast furnaces. He did not think that where power was a matter of consumption of fuel the iron smelting furnaces would be electrically operated. Electrical smelting, at any rate for a long time, would be confined to countries where there were large natural sources of water-power. As to cost of current, in Manchester and Glasgow and other large towns the Corporation would give them a supply at a very low rate indeed for the early part of the day until what was known as "the peak load"—the period of maximum demand caused by the lighting consumption—came on. Mr. Pilkington's question he had anticipated, and the answer would be found in the formula and tables of the Paper. Mr. Ruthenburg's formula was for the arc furnaces in this country, and no doubt was based on actual practice.

MR. GALLON: In the Hering furnace does not the brickwork and also the lining become damaged by the heat?

MR. SCOTT replied that the wear on the resistor portion was negligible; after very considerable service there was not a difference of $\frac{1}{8}$ in. The resistors, of course, had the hardest wear. If a refractory lining for the rest of the furnace was desired, magnesite could well be used for that also. Referring to one of Mr. Hayes' remarks, Mr. Kilburn Scott said that one could not use electrical energy profitably where a big price had to be paid for the current, or where a public supply or cheap generating power was not available. But once a public supply was put in they were always ready to quote a lower price for a power-load than for lighting. Mr. Hayes had made a very good point as to total overhead charges, and the great saving in works' capacity. He (Mr. Scott) remembered that in his grandfather's foundry they could hardly walk along some parts of it because of the great number of jib cranes and other similar equipment. That was very largely done away with when electrical furnaces were installed to run along on the travellers. The fact that the Hering furnace had been used in the United States for melting steel, at the one end, and for dealing with copper at the other showed the tremendous field there was for it. Mr. Swinden had referred to his bias. He (Mr. Scott) had tried to introduce the subject by general references, and to illustrate it by instances; but as the result of his investigations he admitted he was distinctly biassed. He said that that was the best furnace, and if they did not like his opinion, well, they could leave it. (Laughter.) The wear and tear he had already dealt with. After three months' working producing steel these tubes, owing to the pinch action, got a little worn, but they could not find any material difference in size. It might be that after some years' working they would increase the size of those holes a little. A very good point was raised as regards quietening the bath. It could be made as quiet as desired by simply dropping the current, for the pinch effect varied as the square of the current. Coming from 9,000 degs. to 3,600 degs, the quietening was very rapid, but that could be done as slowly as desired.

MR. SWINDEN: In the ordinary furnace you can increase the heat and keep it quiet at the same time.

MR. KILBURN SCOTT: Of course, if you increase the current the "pinch effect" increases.

Referring to Mr. Freeman's question which he had replied to at the time, he ought to explain that the Hering furnace which he had invited them to see at the Northampton Institute was the first brought to this country. A gentleman from Newcastle had referred to Electro-Flex Company's furnace. He (Mr. Scott) did not know that furnace, but he judged, from the description given of it, that it was an induction furnace, and, if so, it was limited in its operation by that fact. Mr. Horne referred to the fact that in the electric furnace any atmosphere could be got over the bath or even a vacuum, or any pressure desired. With the arc furnace there was a great lump of carbon (the electrode) entering the furnace, and it was very difficult to properly seal the furnace and prevent heat losses and the entrance of air.

MR. PILKINGTON asked what was the largest scale on which steel furnaces on this system had been put down?

MR. SCOTT replied that steel furnaces operated on the Hering system had been installed with capacities up to half a ton. The furnace was only just beginning; it was an absolutely new type, quite unlike any other.

The PRESIDENT informed the members that, as the Northampton Polytechnic Institute was only a short distance away and the demonstration occupied only a few minutes, the members would be able to accept Mr. Scott's invitation to see it working before going on the afternoon visits.

Standard Patterns for Motor Work.

MR. J. WORRALL (Luton) then introduced his Paper on "Standard Patterns for Motor Work." This Paper appears on another page of this issue, but owing to pressure on our space the discussion will be printed in our next issue.

Vote of Thanks.

The PRESIDENT, in closing the session, moved that a very hearty vote of thanks be accorded to the members of the London Committee for all the work they had done in preparing for the very successful Convention. He was inclined to think it was more difficult for a committee to organise such a gathering in London than in a provincial town, and in the circumstances a very large proportion of the work had fallen upon the local Branch-President and Secretary. One spoke of the London area, but it should be remembered that some of the London members lived at distances 60 or 70 miles away from London.

MR. MAYER seconded the motion, which was heartily carried, and the members then departed to participate in the visits to works.

VISIT TO WORKS.

The Stratford Works of the Great Eastern Railway Company.

Established early in the 'forties, the Great Eastern Railway Works, situated in North West Ham, about four miles from the centre of the city, occupy an area of nearly 60 acres, and, together with the Temple Mill Works, which are situated about a mile further up the line, find employment for some 7,000 hands. The main offices are contained in a large block of buildings on the east side of, and facing, the Loughton line. Above this, a telephone exchange is established which affords means of intercommunication between the principal officials and foremen in the works.

The erecting and fitting shop is 350 ft. × 142 ft. × 50 ft. high and has accommodation for 40 engines at a time. It consists of four bays running lengthways, the two centre ones being used for erecting apparatus and the two side ones for fitting, boiler mounting and heavy machinery. There are six longitudinal pits in the central bays, and each bay is provided with a 30-ton overhead crane driven by flying ropes. Two auxiliary 3-ton travelling cranes are also installed in each bay for dealing with lighter work. The shop is provided with portable machines for cutting off tube ends, facing safety-valve seating, boring and facing cylinders, steam jets and slide valves. Portable pneumatic drills are used for the most of the holes which have to be drilled while the engines are being erected. The stay holes in the fire boxes are also tapped by portable pneumatic machines. It is worthy of note that it was in this shop that a standard goods engine was built in 10 working hours, this establishing a record which still holds good. The two side bays of the shop are devoted to fitters' benches and heavy machinery, and above this are the shop for leather fittings and a fitting shop devoted chiefly to work connected with the Westinghouse brakes.

The chemical laboratory and the works' drawing office are also situated above one of the bays. The machine shop, formerly 132 ft. × 136 ft., has recently been extended by some 8,730 sq. ft. Space for this extension was made available by the demolition of the iron foundry and auxiliary shops, a new foundry, together with the necessary shops, having been erected on the west side of the line. The machine shop contains a very comprehensive range of up-to-date machinery. In addition to the machines, such as are met with in the majority of engineering works, mention may be made of a number of automatic turret lathes for making bolts, studs, etc., in large quantities, and also some special piston-head, poston-rod, and metallic-pattern lathes, together with large slotting and milling machines on which such parts as engine side rods and connecting rods are machined. Attached to the machine shop is the tool shop in which most of the small tools used in the works are made.

FIG. 1.—IRON FOUNDRY AT THE GREAT EASTERN RAILWAY WORKS, STRATFORD.

The boiler shop is 220 ft. × 240 ft., with a side bay 77 ft. × 46 ft. Here are made many pneumatic tools, such as hammers and corking tools, and also tools for hydraulic power, the latter being applied to rivetting machines and to two large flanging presses, which are capable of exerting pressure up to 236 and 200 tons respectively. Adjoining the boiler shop are the steam hammer, smiths' shop, and spring shop under one roof and covering 34,490 sq. ft. of ground. The steam-hammer shop is served by eight furnaces, four of which are heated by producer-gas from Wilson producers, and four coal-fired. The hot gases from the furnaces pass

through four boilers fixed in the shop above the furnaces, and these, with outside assistance, supply steam for the hammers, which are being worked with dry steam obtained from a receiver connected with

used in the shop, which contains a "Tabor" pneumatic and two hand-moulding machines. The shop is ventilated by a 4 ft. diameter Blackman fan fixed in the wall.

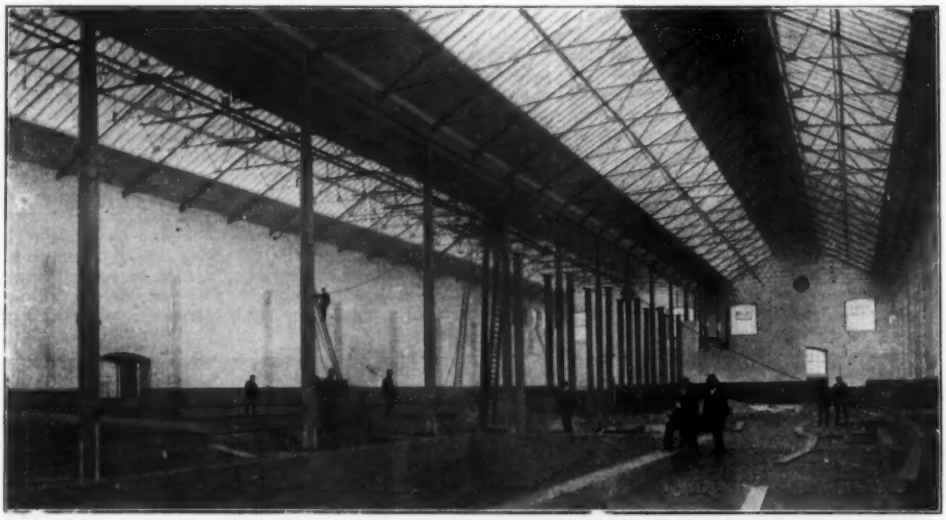


FIG. 2.—IRON FOUNDRY AT THE GREAT EASTERN WORKS IN COURSE OF COMPLETION; SHOWING ONE OF THE MOULDING PITS.

the boilers. The spring shop has in it a testing machine for testing each spring after manufacture.

Another block of buildings contains the copper-smiths' and brass finishing shops and a brass foundry. The brass foundry has nine ordinary furnaces, one of which is fired with liquid fuel, and from each of these eight charges per day may be taken. There

The copper-smith's shop also contains a set of iron pots heated by coal gas for melting white metal. This building is similarly ventilated. In the brass-finishing shop, small brass work, such as cocks, whistles, injectors, etc., are machined and finished, and this shop is connected with the stores below by means of a power hoist.

FIG. 3.—PATTERN-MAKERS' SHOP AT THE GREAT EASTERN RAILWAY WORKS, STRATFORD.

is also an open-hearth brass-melting furnace fired with liquid fuel. This furnace has a capacity of about 8 cwts., and is capable of melting about 32 cwts. of brass per day. Plate patterns are largely

Adjacent to this building is the hydraulic power house from which is supplied the whole of the power required in the different hydraulic presses, rivetters, lifts, cranes, etc. The plant consists of two com-

plete units, comprising engine with a pair of cylinders 17 in. in diameter by 24-in. stroke, buckets of 4½ in., and the rams 3 5/16 in. in diameter. The accumulator weighs 82 tons, and works at a pressure of three-quarters of a ton to the square inch. The engines take their steam from three locomotive-type boilers. The wheel shop, situated above the north side of the smiths' shop, is 190 ft. by 70 ft., in two bays, each of which is served by a 6-ton overhead traveller, while a small shop on one side contains the lighter machinery. The complement of tools includes 16 wheel lathes, with face blades ranging up to 9 ft. in diameter and nine lathes for axles, crank pins, etc.

Crank axles, which are forged of Bessemer or open-hearth steel, are first turned and, if the webs are oval, are machined for hooping. After the hoops are shrunk on by being heated to a black heat and cooled down in water, the keyways are cut in a duplex milling machine and the wheels are forced on to the axles by a hydraulic press at a pressure of from 80 to 120 tons. Next to the wheel shop is the axle-box shop, which is specially devoted to the preparation of those engine parts which work on the axles, viz., axles boxes, eccentrics, etc. From here they are taken to an adjoining shop where they are fitted up on the axles ready for putting under the engines in the erecting shop.

A weighbridge for weighing the engines and used in connection with the erecting shop is situated near the general offices. It is 40 ft. long and is divided into 12 tables, each capable of independently weighing up to 12 tons, and thus enabling weights on individual wheels to be recorded and, if necessary, adjusted. In the carriage department, which is also on the east side of the Loughton line, the whole of the Company's passenger train stock is built and repaired. It contains extensive saw mills, as well as stock, body, fitting and machine shops, etc. Also shops devoted to sewing machines and polishing, in which only female labour is employed.

As previously stated, the iron foundry is situated on the west side of the line, and this, together with the auxiliary shops, forms a compact block of buildings. The foundry is 250 ft. by 160 ft., and is covered by two bays. One side of the shop is mainly devoted to floor moulding, and is provided with brick-lined pits for casting, in addition to the usual sand floor. The other side is plate floored and occupied in part by machine moulders. The installation of moulding machines comprises one hydraulic "Bonvillain," with three heads, used chiefly for brake blocks; two-edge hand machines, used for brake blocks, safety valves, rubbing pieces, etc.; four small hand machines for axle boxes and double guides; a small hand machine for buffer shoes and axles-box bottoms; and a "Hermann" pneumatic jarring machine used for axle-boxes. The foundry is capable of turning out castings up to 10 tons in weight, but the largest castings normally produced are the engine cylinders, which, cast in pairs, range in weight from 2 to 3 tons. Normally some two pairs of cylinders are turned out per week, whilst the total amount from the foundry per week is approximately 70 tons.

At one side of the shop, and arranged in sequence, are a sand-pit and mixing-room, containing two return sand mills, a sand-sifting machine, and a core-makers' shop, where light cores are prepared. Adjoining this last are four core ovens, with their

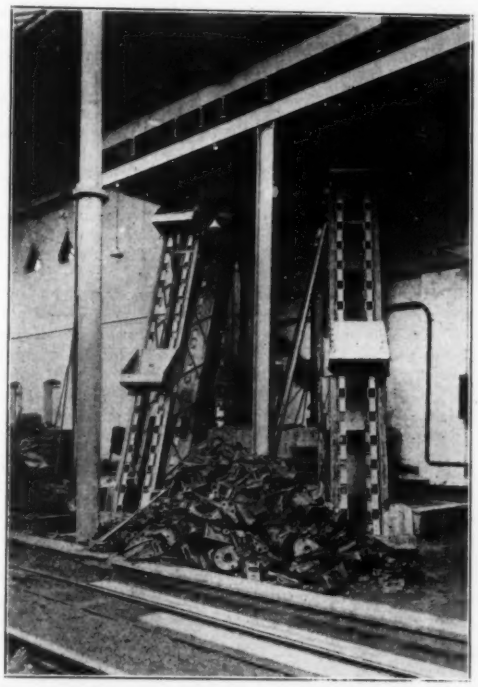


FIG. 4.—CREEPERS AT THE IRON FOUNDRY CUPOLA.

FIG. 5.—PATTERN STORES.

GREAT EASTERN RAILWAY WORKS, STRATFORD.

accompanying furnaces. The largest of these ovens is 25 ft. by 20 ft. This is used principally for engine cylinders. The core ovens are coke fired. The flues from the furnaces are carried over the ends of the furnaces and thence lead the heated air to grids in floors in the ovens, eventually escaping through openings at the top. There are four cupolas, two capable of bringing down 6 tons of metal per hour, and two of half that capacity. These are mechanically charged by means of bucket elevators, which allow of more regular and continuous charging than is obtainable by means of a lift. Blast is supplied from four motor-driven Root's blowers, which are installed in an underground room. In this room is also a Reavell air-compressor, which supplies air for use throughout the foundry, and a small centrifugal pump, which is used for drainage purposes.

Beyond the cupola plant is a shop containing fitters' benches and stores, and at the end of the main shop the trimmers' benches are situated. The foundry, which is a very lofty building, is electrically lighted throughout. The floor is served by two 15-ton and a 3-ton electric overhead traveller in each bay, whilst adjacent to the core-ovens is a 1-ton hydraulic jib crane for lifting crucibles and large cores. Outside the shop, and beyond the trimming shop, is a 5-ton electric derrick for loading the finished work. At the opposite end is the scrap stock bin with a capacity of 300 tons. Here also are installed two hydraulic breaking machines for scrap and pig-iron, together with a weighing machine.

Alongside the foundry, on the ground floor, is a carpenters' shop, devoted chiefly to locomotive work, and the pattern stores, a room 160 ft. by 45 ft. This is equipped systematically with racks for the patterns, which are numbered and duly indexed. The stores are steam-heated throughout, and communicate through a steel door with the foundry. Above the stores and carpenters' shop is the pattern shop, 200 ft. long by 45 ft. wide, containing the usual complement of pattern-making machinery. It is electrically-lighted, and ample provision is made in the way of fire-extinguishing apparatus. An electric lift is arranged between the shop and the stores below, and thence to the foundry for the purpose of conveying large patterns in either direction.

Liquid-fuel apparatus is in use at the Stratford Works on the stationary boilers, in the gasworks and on rivet forges in the boiler shop, as well as on certain of the Company's locomotives. The fuel distributing station is hard-by the running sheds, the fuel on arrival being emptied from the tank wagons into a series of underground storage tanks of a total capacity of 50,000 gallons. From thence it is drawn by a rotary pump through 3-in. mains to a high-level cylindrical reservoir holding 40,000 gallons. The engine tanks are filled from the ground wagons through 4-in. pipes, the flow being controlled by sluice valves at the extreme end of the arms. The oil-gas works comprise a series of buildings for the manufacture of gas for lighting carriages, and are provided with a photometer dark room, etc., for testing purposes. The gas is distilled from the oil in cast-iron retorts. After generation it is passed through condensers to the gas-holders. It then passes through the meter compressors, by which it is forced into high-pressure gas-holders at a maximum pressure of 10 atmospheres. Both high-pressure gas-holders have a capacity of 5,000 cub. ft. The quantity of gas made per week in the summer months is 400,000 cub. ft. and 600,000 cub. ft. in the winter months, the annual production being 25,000,000 cub. ft.

Works of the London General Omnibus Company, Limited.

Before briefly describing the Walthamstow works of the London General Omnibus Company, it may be interesting to refer to the early history of the motor-'bus and the subsequent development of the industry.

The first motor-'bus to be run in regular service was a steam car belonging to the Road Car Company, put upon the Bayswater Road in 1902, though a prior attempt had been made at mechanical traction for 'buses in 1907. There is, however, no evidence that this was ever put into service. The first company promoted solely to run motor-'buses was the Vanguard Company, or, as it was then known, the London Motor Omnibus Company, which commenced operations in 1905. That year and the two following witnessed the formation of a large number of companies for the running of motor-'buses, few of which ever paid a dividend. Many were absorbed by other companies, or reformed under new names, so that of the 42 which are known to have operated in London, only some ten remain.

To supply the needs of these early companies many makers introduced motor-'bus chassis, few of which were of well-considered design, and in effect many were unreliable and inefficient, and the commercial vehicle generally fell into very bad repute among other trades. In 1909 the London General Omnibus Company started building their own chassis, and constructed 60 of the "X" type, which were the first to be built under the new police regulations. These were followed in 1910 by the well-known "B" type, and it was due to their success that the company was raised to its present highly prosperous position. The reliable and efficient running of this vehicle proved that the motor-'bus could be a sound investment, and has had a very far-reaching effect upon the commercial-vehicle trade. The London General Omnibus Company is the leading one now operating in the City of London. It was formed as a horse-'bus company in Paris in 1885, and first adopted motor traction in 1904. In 1908 it amalgamated with the Vanguard Company (which was itself formed of four previous companies), and the London Road Car Company. In January, 1911, it took over the Great Eastern Motor Omnibus Company, and in October of the same year the last horse 'bus was withdrawn from the streets.

The Walthamstow Works, situate in Blackhorse Lane, about four miles from the City, were established by the Vanguard Company in 1906 with a staff of six men, who worked in a shed. Although the present company started in a comparatively small way, the management were alive to the future possibilities of the industry, and planned the works with a view to considerable extension. How well these plans were conceived is testified by the complete continuity of operations in the present works, which cover some 155,000 sq. ft., and find employment for 1,250 men—a development of a works which four years ago covered a floor space of 3,415 ft. The company have still upwards of three acres of land available for further extensions.

The works consist of five main blocks of buildings. Entrance is by way of the Timekeeper's Office to the managerial buildings, which are situated above the View Room, where all parts are inspected, and, if necessary, calibrated, before being passed to stores or the erection department, as the case may be.

A second block of buildings covers the Old Machine Shop, so called because it was the first erected, though, like the rest of the shops, it is laid down on strictly modern lines. It is covered by a saw-tooth roof with north lighting. The machines

are arranged on either side of a central bay, one side being devoted to automatic machinery, for the most part by Alfred Herbert, Coventry, and the other to milling, drilling and slotting machines. The supports on each side of the bay carry a raised platform upon which are installed the motors for operating the line shafting. The motors are standardised throughout the works and are of 20 h.p., by Messrs. Veritys, Limited, Aston, Birmingham. Each line of shafting is driven by its own motor. The works switchboard is also situate in this shop. Current is taken from the local mains at 460 volts for power and 230 volts for lighting. Adjoining is a well-equipped laboratory and test house. A careful analysis is made, and mechanical tests are taken of all material used. Included in the Testing House

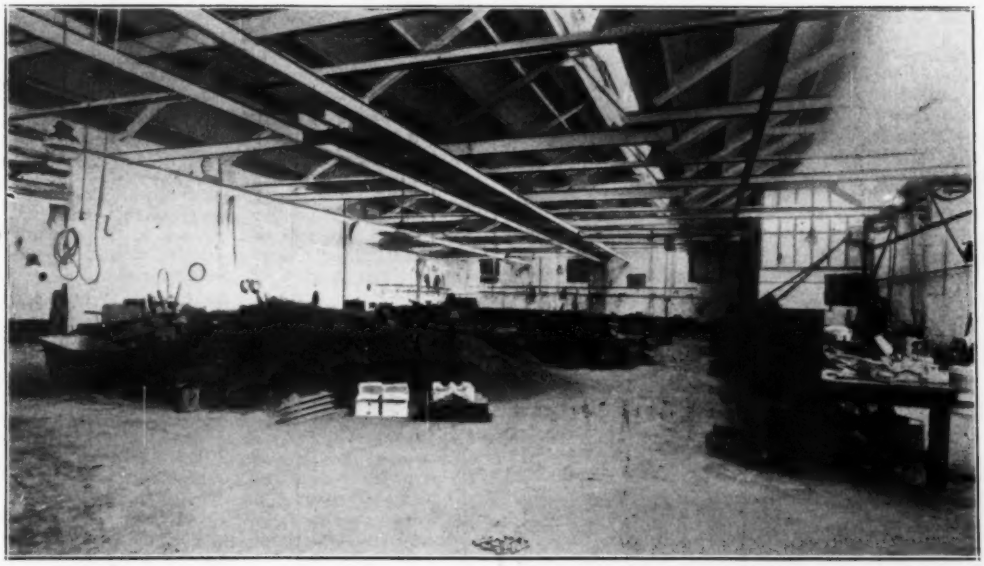


FIG. 1.—VIEW IN THE FOUNDRY AT WORKS OF THE LONDON GENERAL OMNIBUS COMPANY, WALTHAMSTOW; FETTLING SHOP WITH POWER HOUSE AT REAR IS SEEN ON LEFT.

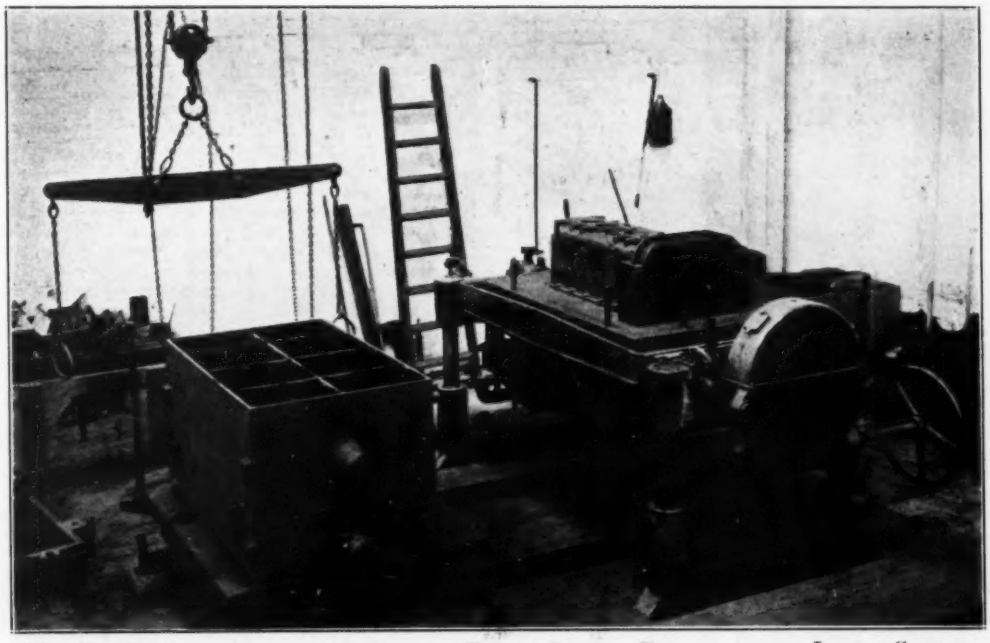


FIG. 2.—HYDRAULIC MOULDING MACHINE FOR ENGINE CASINGS; FOUNDRY OF THE LONDON GENERAL OMNIBUS COMPANY, WALTHAMSTOW.

equipment is a Fremont (Paris) machine for hardness and shearing tests, and a 60-ton Buckton (Leeds) machine.

The New Machine Shop is contained in a further block of buildings. This shop is equipped with a number of fine tools, amongst which mention may be made of Pratt & Whitney multi-spindle drills, Archdale lathes, automatic machinery by Messrs Alfred Herbert, Limited Coventry, etc. These tools occupy one side of the bay, whilst the other side is taken up with the Tool-room, Tool Stores, Brass-Finishing Shop, Ignition Shop, and the Experimental Shop. As in the case of the Old Machine Shop, each line of shafting is driven from a 20-h.p. motor carried on a raised platform. Each of the auxiliary shops are partitioned off, and are entirely self-contained.

A fourth block of buildings covers the Chassis Shop, upon one side of which the chassis are built up and upon the other the back axles assembled; the Engine Shop, where the engines and gear boxes are assembled; and adjoining these are the Case Hardening Shop, served by six coke-fired furnaces, each fitted with electric pyrometers; the millwrights' shop, a well-equipped pattern shop, sand-blast room, and the Engine Test House.

The Foundry and Melting Shop occupy the central position in the last block. The foundry was extended by some 11,000 sq. ft. in September last. An

FIG. 3.—CORNER OF THE CASE-HARDENING SHOP; WORKS OF THE LONDON GENERAL OMNIBUS COMPANY.

interesting unit of the plant is the hydraulic moulder for moulding engine casings, and upon which a complete mould is turned out every hour; prior to its adoption the same work hand-moulded took 22 hours to perform. There are also a number of hand-moulding machines. The Fettling Shop, with the usual equipment, including a rotary sand-blast apparatus, occupies a side bay, a further portion of which is walled off for the foundry power-house, in which is installed a Reavell compressor, belt-driven from a 20-h.p. Verity motor, and supplying air for use throughout the foundry. The hydraulic pump, driven from a 20-h.p. motor and the accumulator are also installed in this room. In a gallery at one end of the foundry ample lavatory accommodation is provided for the men. The melting shop contains eighteen coke-fired and one oil-fired furnace, with three coke-fired drying ovens and the usual auxiliaries. Trolley ladles are employed to take the metal from the melting shop to the foundry.

Adjoining the foundry are the tinsmiths' shop, the smiths' shop and the garage. In the first-named the radiators are finished and the mudguards, etc., built up, and here an oxy-acetylene plant is installed. The smiths' shop contains eight hearths, and is served by two pneumatic hammers (Pilkington Bros., Bamber Bridge, Preston) of one ton and 15 cwts. respectively. In the garage the chassis are delivered and examined before passing to the works. Here also a raised platform. Each of the auxiliary shops is partitioned off, and entirely self-contained.

Walking round the stock yard one may study the evolution of the motor-'bus wheel from the old type with heavy rim and solid spokes to the present type with its lighter rim and hollow spokes. These last are castings worthy of close inspection.

Messrs. Fraser & Chalmers, Limited

The works of Messrs. Fraser & Chalmers, Limited, which have previously been the subject of a descriptive account in our issue of February, 1912, are situated on the Thames, at Erith, Kent, with wharf for river shipment, and connection with the lines of the South-Eastern and Chatham Railway. The shops were begun in 1890, and have been gradually enlarged and added to until now a force of over 1,400 men is employed. Up till 1901 the Company also owned works in Chicago, and shipments were made partly from America and partly from Erith. At present the whole of the Company's manufacture is concentrated at Erith. The English Company was formed for the purpose of establishing in England the manufacture of high-class modern mining machinery, and as a first step thereto the then well-known American business of Fraser & Chalmers was bought, and later was sold when it had served its purpose of building up the English trade. The shops are fitted with modern tools of the best types built in England, United States, and Germany, and special provision has been made for the erection and testing of large engines, pumps, and compressors. The tools and testing floor for the manufacture of high- and low-pressure steam turbines of the Rateau type, put down in 1905, have produced a very large number of these machines which are now in use. Among the great variety of machinery which is made at Erith, the following may be mentioned as receiving special attention and representing special experience in manufacture:—Driving engines, compound winding engines, Whiting hoists, Riedler & Gutermuth pumps and compressors, crushers, stamp mills, grinding pans, tube mills, cyanide plants, concentration mills, Wilfley tables and slimers, smelting furnaces, Bessemer converter plants, roasting furnaces, Blaisdell excavators, continuous filters, coal-screening and washing plants, boilers, Rateau steam turbines, Rateau centrifugal pumps and turbo compressors, ventilator fans, diamond washing plants, heavy American type of gold dredges, and the necessary accessories for the various plants. A modern type of boiler for burning dust fuel, and known as the Bettington boiler, is in use at the works, and has proved very efficient. Its high efficiency and power of using inferior slack with as much as as 30 per cent. of ash marks out a special field for its employment. Particular interest was naturally evinced in the foundry, which is, we believe, the largest general castings foundry in the South of England.

Woolwich Arsenal.

An excursion which attracted a large number of members was to the Royal Arsenal at Woolwich. Owing to the limited time at disposal it was not possible to see all those sections of the Arsenal which are open to visitors, but sufficient time was allowed to see the more interesting portions of the Royal Carriage Department, the Royal Gun Factory, and the Royal Laboratory, which are the three main departments into which the Arsenal is divided. The features examined included the main machine shop, foundry, and wheel factory of the Royal Carriage Department; the south boring mills, radial crane, heavy turnery, forge (with 3,000-ton press), and breech mechanisms of the Royal Gun Factory. In the Royal Laboratory the visitors were shown the shell foundry (which has the Tropenas system), the brass foundry, the small arms bullet plant, and the main factory.

Until comparatively recent times Woolwich was more celebrated for its dockyard than for its Arsenal, and during the reign of James I. and subsequently, many of the largest warships of the British Navy were built here. The dockyard, however, ceased to exist as such in 1869, and its buildings have since been utilised by various branches of the military service as storehouses and workshops.

Royal Carriage Department.

The Royal Carriage Department manufactures and repairs gun mountings, field carriages, and military vehicles of every description. It still employs many woodworkers, although, so far as gun carriages are concerned, steel has largely displaced timber for constructive purposes. Ammunition and rifle cases and other miscellaneous stores are also made here. In the wheel factory are to be seen some of the most modern and ingenious machines in use in this country for wheel construction. Amongst others, the spoke-turning, thoating and facing machines are conspicuous, whilst those for felloe turning, rounding, and polishing, are also noticeable. The various parts of the wheel are assembled by means of hydraulic presses. This machinery is also utilised for making heel pegs, tent poles, mallets, etc. In the carpenters' shop is a felloe bending machine, and the hydraulic presses for clamping together boxes and chests, also special machinery for small arm ammunition boxes. The wood machine shop is fitted with sawing, planing, boring, mutlile drilling, mortising, tenoning, and dovetailing machines. The operation of dovetailing is particularly interesting, and is performed with the greatest rapidity. In accordance with modern practice, these are driven from underground, and shavings, chips, and dust, are also drawn away underground by means of exhaust ducts.

The tools in the main machine shop are among the largest of their kind in the Arsenal, and many of the operations performed approximate more to ordinary engineering work than in other shops through which the visitor passes.

Royal Gun Factory.

The north boring mill is one of the older sections of the Royal Gun Factory wherein is carried on the manufacture of guns of all classes and calibres, except small-arm rifles and machine guns. Those actually turned out at the present time vary in calibre, or diameter of internal bore, from 3 in. up to the latest type of 12-in. rifled gun with a length of 45 ft. The weight of these weapons, without accessories, ranges from 3 cwts. to 60 tons. Ordnance of larger calibre and considerably heavier weight were manufactured in former years, but they have been superseded by the modern gun of smaller calibre, greater length, and very much higher muzzle velocity and penetrating power.

The machine tools are, on the whole, of a very much larger nature than those in the other departments of the Royal Arsenal. They therefore lend themselves very readily to single or group electric motor driving. The current is supplied from a central power station for the Arsenal generally. Considerable use is made in this factory of magnetic clutches. It is interesting to note that the gun factory boring mills were worked by horses up to as recently as 1842.

In the main turnery can be seen many large machine tools engaged on special operations incidental to the manufacture of guns. In the forge may be seen a large 40-ton steam hammer. This hammer, when first erected, was considered a wonderful piece of work, and was quite unique in its way, but here, as in many other engineering works, the steam hammer of abnormal size has given way to the superior utility of the hydraulic forging press, a fine example of which is to be seen in the west forge. The press in question can exert a pressure on large forgings of 3,000 tons, and turns out better and more uniform work than a steam hammer.

In the south boring mill are carried on the various operations of rifling large guns and also the subsequent lapping, gauging, and inspection of the same. Rifling consists of cutting along the bore of the gun a number of shallow spiral grooves or flutes. When the gun is fired a copper band surrounding the base of the projectile is forced into these grooves, causing the projectile to revolve on its longer axis and steadying it in its flight. Up to about 1856 all guns were smooth bore. The machine tools in this shop are, in the majority of cases, quite special to the particular operations of gun manufacture, and they are mostly driven by individual electric motors.

Royal Laboratory.

The Royal Laboratory manufactures ammunition of all kinds, including shells, fuzes by which the shells are detonated, cartridges ranging from the small 0.303 in. for rifles to the large self-contained cartridges for quick-firing guns, and rockets and tubes. A large number of the metal components required for these stores and also the metal cases for packing ammunition are made in the main factory. In contains over 600 machine tools, amongst which special mention may be made of a large number of automatic machines of the most modern types. These machines are so designed that, with a minimum amount of personal attention, they will, from plain bar, produce components in a finished condition.

In the small arms bullet factory is carried on the manufacture of bullets for rifles. These bullets consist of a soft lead core and an envelope. The former gives sufficient weight to allow the bullet to carry the required range and assists in keeping it stable during flight, and the latter, made sufficiently hard to take the rifling in the barrel of the gun, causes the bullet to rotate, and gives stability and low trajectory.

In the manufacture of the soft cores, lead of a particular composition is placed in hydraulic presses, whence, by the exercise of great pressure, it is squirted in the form of rod and cut into lengths as required. The envelopes are punched from long thin strips of material and are gradually pressed and drawn until they attain the required dimensions and shape. The core and envelope are then brought together to form the completed bullet.

In the quick-firing cartridge factory there is much of interest. So far as the ammunition itself is con-

cerned, it involves the use of an explosive charge already made up and ready for insertion in the breech of the gun. These charges are usually contained in brass cases, and the system is really an extension to large ammunition of the usual design of small arms ammunition. The production of "Q.F. cases," as they are commonly called, comprises:—(1) mixing and casting ingots of special composition; (2) rolling these ingots into strips; (3) punching the strips into blanks or round discs of various sizes and thicknesses; (4) converting the blanks into "cups"; (5) elongating the cups by the process of drawing, the number of "draws" varying with the sizes to be produced; (6) heading or forming the shoulders on the drawn cases, together with trimming and subsequent minor machine operations. It will be readily understood that this series of operations necessitates very severe treatment to the metal, and to enable it to satisfactorily undergo these operations it has to be thoroughly annealed at the various stages of manufacture. The machinery here is mostly hydraulic, the pressure used ranging up to three tons per square inch, the actual pressures required to carry out some of the operations being as much as 1,200 tons.

In an annexe some of the preliminary operations of casting and rolling the metal are performed, and on the upper floor the machining operations necessary to complete the cases and to produce the smaller components such as anvils, caps, etc., are carried out.

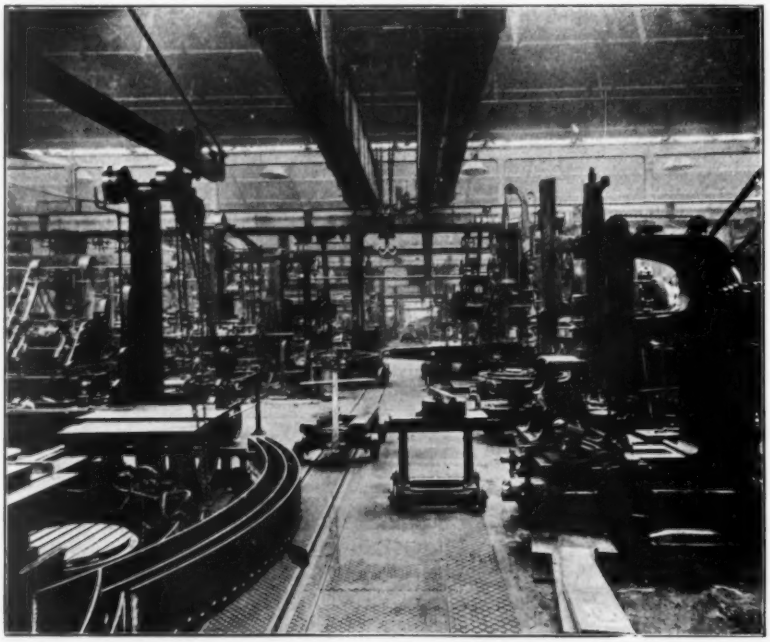


FIG. 1.—MAIN MACHINE SHOP; WOOLWICH ARSENAL.

In the shell foundry the bodies of the various natures of shot and shell are produced and pass through the requisite operations preparatory to being filled with explosive charges or fitted into quick-firing cartridges. The equipment of the department comprises 11 cupolas for the production of iron castings and molten iron for conversion to steel, a number of underground furnaces for the production of cast crucible steel shell of any special character, and three Tropenas converters for the production of the larger sizes of cast steel shell. The Tropenas process was adopted in the shell foundry in 1897, the installation being one of the first of its kind in this country.

General Particulars.

It is not easy to assign even an approximate date to the original foundation

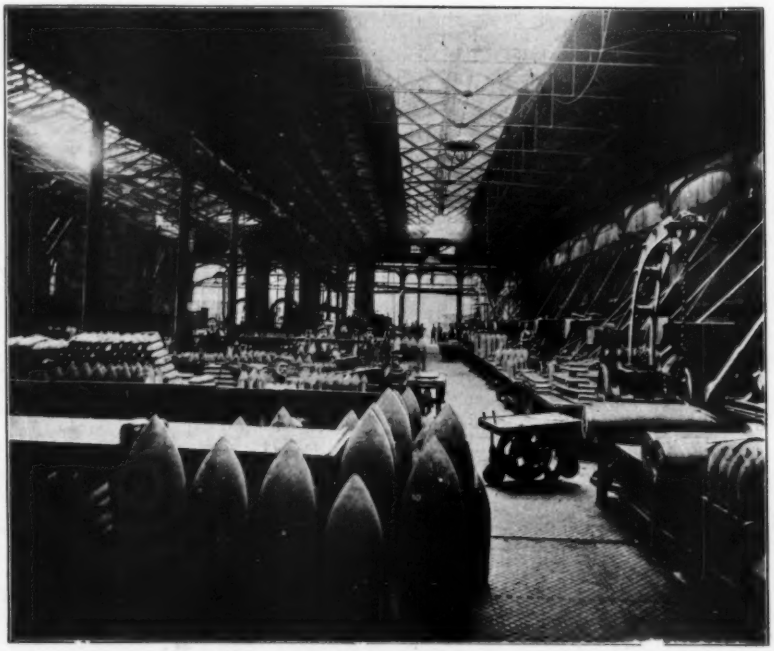


FIG. 2.—TRIMMERS' SHOP; WOOLWICH ARSENAL.

of the Royal Arsenal. There is, however, no doubt that the Royal Carriage Department and Royal Laboratory existed in embryo in the 17th century, and that ordnance were proved here at the same period.

On the site now occupied by the pattern room for laboratory stores, it is probable that a building existed as far back as the 14th century. This building came into the possession of the Government about the middle of the 16th century, and was occupied by the Master-General of the Ordnance, a position held for some years by Prince Rupert. Incidentally, it may be observed, that the present Arsenal wharf is built on an old riverside terrace formerly known as Prince Rupert's Walk. The existing laboratory pattern room was erected in 1719 from designs by the famous architect, Sir John Vanbrugh. It was for some years used as a place of instruction for the Royal Artillery Cadets. Adjoining the building was a tower, pulled down in 1786.

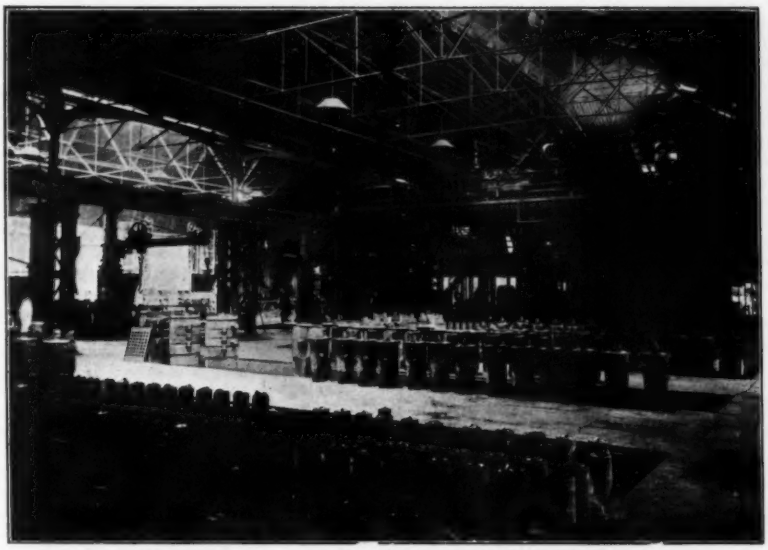


FIG. 3.—IRON AND STEEL FOUNDRY; SHELL CASTING DEPARTMENT AT WOOLWICH ARSENAL.

In 1716 the casting of ordnance was removed from Moorfields to Woolwich, and the old brass foundry, now used as a tinmen's shop, was then erected in which to carry on the work. This foundry is also said to have been built to the design of Sir John Vanburgh. The official who was then responsible for the manufacture of guns, called the Proof Master, occupied a residence alongside the foundry, and over one of its doors was placed a handsome stained window, which has since been removed to the new offices of the Chief Superintendent of Ordnance Factories.

The description "Royal Arsenal" was first given to the establishment in 1805. Prior to that it was known as the "Royal Warren," and in still earlier times as "Woolwich Tower Place."

Convict labour was largely used in the extension works up to 1856, and the remains of prisoners have not infrequently been found in the course of excavations, in some cases with shackles still attached.

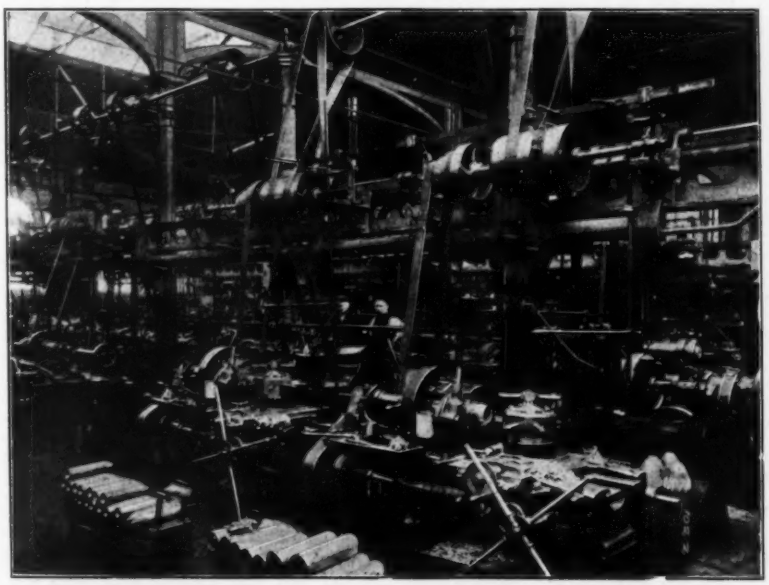


FIG. 4.—PART OF SHELL TURNING SHOP; WOOLWICH ARSENAL.

There are various military and naval establishments located within the boundaries of the Royal Arsenal, such as the Army Ordnance Department, the Army Inspection Department, and the Naval Ordnance Department. The Ordnance Factories comprise:—(*a*) The Royal Laboratory, which is mainly concerned with the design and manufacture of ammunition. (*b*) The Royal Carriage Department, in which are designed and manufactured gun-mountings and carriages and military vehicles of all descriptions. (*c*) The Royal Gun Factory, which designs and manufactures guns and torpedoes. (*d*) The Building Works Department, which constructs and maintains all Arsenal

buildings, roads, and railways, and supplies electric and hydraulic power, and gas. These, with the gunpowder factory at Waltham Abbey, and the small arms factory at Enfield Lock, constitute what are collectively known as the Royal Ordnance Factories.

The extreme length and maximum breadth of the Arsenal are rather more than three miles and one mile respectively. Its total area amounts to about 1,285 acres, of which 407 acres are contained within the boundary walls and 89 acres are covered with buildings. For the transport of stores and material there are 15 miles of broad gauge railway, served by locomotives, chiefly of the four-wheel coupled type; also 32 miles of narrow-gauge railway, served by steam and oil locomotives. A properly organised passenger service is also a feature of this railway system, working to a regulated time table, with stopping places en route. Such accommodation effects a very considerable saving of time in traversing the somewhat extended distances. Along the main avenues within the Arsenal asphalt tracks for cycle traffic have also been laid down and are largely used.

The number of persons employed in the Royal Arsenal varies considerably according to circumstances. During the busiest period (1901) of the South African War the numbers exceeded 11,000 in the Royal Laboratory, 3,700 in the Royal Carriage Department, 3,500 in the Royal Gun Factory, and 2,400 in the Building Works and Central Departments.

The Gayley Dry-Blast Process.

Dr. James Gayley recently gave an interesting account of the evolution of the dry-blast process for blast furnaces associated with his name, setting out the results obtained at several works as follows:—Works A obtained a decrease in coke consumption of 10.5 per cent. and an increase in output of 23 per cent.; works B obtained a decrease in coke consumption of 6 per cent. and an increase in output of 15.3 per cent.; works C obtained a decrease in coke consumption of 9.8 per cent. and an increase in output of 11.8 per cent.; works D obtained a decrease in coke consumption of 10.5 per cent. and an increase in output of 16 per cent. Proceeding, Dr. Gayley pointed out that the results obtained at different plants are modified by the raw material used, and the personal equation of the management enters into it. "The results given above," he said, "are taken from works in three different countries. The claim I personally make for the process is that with an increase in output of 10 per cent. the saving in fuel per ton of iron will be reduced 10 per cent., and I consider this conservative. One of the advantages obtained through dry air is the elasticity it permits in the furnace operations to meet business conditions. If trade is dull the furnace can be operated to secure the maximum of fuel economy with a small increase in output, but when trade is "booming" and pig-iron is in demand, and increased output is more desirable than a saving in fuel, the furnace can readily be made to respond. In addition, it is found that the furnace works with greater regularity, and in consequence a more uniform metal is produced, and a required grade of metal can be made with precision. In low-silicon irons the sulphur does not increase as it does when natural air is used. The saving in coke effects a corresponding saving in the limestone necessary to flux the ash of the coke, and there is less phosphorus entering the metal. As the furnace charges settle more regularly, there is less fine ore carried over with the gases."

THE gross value of the estate of the late Mr. H. J. Pearson, of the Beeston Foundry Company, Limited, is £51,758, with net personalty £49,436.

Points for Young Moulders.

Never lose sight of the fact that iron gaggers are heavier than the same proportion of sand.

A hanging body of sand would stand a better chance of being lifted by having no gagger, than by having a lot of short gaggers coming up but a short distance between the bars.

Keep the top of the pouring runners free from loose sand around the hole, by packing it firmly with the hand.

Never pour a ladle of iron without skimming; and stand so that you need not move after commencing to pour.

If the castings are light, they should not be left in the sand over night, as they are apt to get rusty.

Castings that will keep red-hot for two or three hours after being poured, are best covered over with sand until they become cold, since leaving them exposed to the effects of the atmosphere destroys the good colour of a casting, and its strength.

Dry-sand moulds should generally be rammed harder than green-sand moulds.

Dry sand does not require as much venting as green sand, and many moulds can be cast without venting.

Less gas is created with dry sand than green sand, and if a mould is thoroughly dried, there is no steam to contend with.

When ramming dry-sand moulds, be just as careful to avoid hitting the pattern with the rammer as in the case of green-sand moulds.

All joints made on dry sand or loam moulds must be pressed or sleeked down, so as to leave a fin upon the casting, as this class of mould would crush, if the joints were left as the mould was parted.

According to an old maxim, it is better to have a fin than a crush, the truth of which many old experienced moulders have found to their sorrow.

When finishing dry-sand moulds, sand should never be patched or sleeked on smooth or sleeked surfaces.

Dry-sand mixtures vary according to the kind of sand or loam used; almost every shop has a different way of mixing dry sand and loam.

A close mixture of loam or dry sand is very liable to scab, while if it is too open the mould will not stand the dropping or washing effect of the iron when poured.

Experience is generally required to get the correct proportions of sharp and loam sands to mix together, though some few places have a natural loam or dry sand that requires no such mixing.

Dry sand or loam moulds, if not thoroughly dried, generally cause a casting to become scabbed.

A casting poured hot will finish up cleaner than one poured dull, providing both are free from scabs.

Cast iron will stand more strain slightly warm than when very cold, and the same is true of wrought iron. In very cold weather, chains should not be strained in hoisting as much as in the summer time; sometimes it is best to warm a cold chain before hoisting a heavy weight.

It is not safe for two-ply chains to hoist any more than:—20 tons with a 1-in. chain; 14 tons with a $\frac{7}{8}$-in. chain; 10 tons with a $\frac{3}{4}$-in. chain; 6 tons with a $\frac{5}{8}$-in. chain; 3 tons with a $\frac{1}{2}$-in. chain. If the chains are not made of the best iron, they should not be used to hoist more than two-thirds of the weights given.

When learning your trade, don't let your conceit run off with your common sense, as such conduct makes your superiors dislike you, and also hinders your advancement.

Whenever you want to know anything, if you have friends they will tell you, and without such help you can do but little.

Blast-Quantity and Pressure in Cupola Working.*

By F. J. Cook.

The author considers that no apology is needed for bringing before a body of foundrymen a research on cupola working. Probably from the very inception of its use, the cupola has been quite a burning question—in more senses than one—with those who have had to exercise control over its management. It has generally been considered that each cupola is a law unto itself, and in many instances in the past one might also include the cupola attendant in the same category, there being times when probably more thought was spent on how to manage the attendant than on the cupola itself. That the results of the cupola are amenable to proper scientific laws is now, perhaps more than ever, being generally conceded, and during the last two or three years quite a number of Papers have been read before societies, in which observant workers have given the results of their experience. In most cases, however, these have consisted mainly of opinions rather than the results of regular research. On many occasions it has been stated that reliable data are required on the air-blast before the working of the cupola can be put upon a scientific basis, and the present Paper contains particulars of a research undertaken with the object of ascertaining the relation of blast quantity and pressure to quantity of iron melted in the working of cupolas. In most of the theories which have been advanced up to the present time the quantity of iron melted per hour has been supposed to bear a definite relation to either the pressure or quantity of air supplied in the blast. But the inconsistencies arising from the attempted application to different cupolas of formulae based on these theories, have led the author of this Paper to look for some more reliable, if slightly less simple, law which would apply to all cupolas, and by means of which cupolas might be standardised and worked with the maximum economy and efficiency. In order to investigate such a law, it is essential that it should be possible to measure both quantity and pressure of air-blast with reasonable accuracy, and it is also advisable that it should be possible to vary each of these factors independently of the other to some extent. Such independent variation is bound to occur naturally in a small degree, owing to variation in the closeness with which the cupola contents pack themselves; but it might, of course, be produced artificially by contracting the area of the tuyeres.

The author has for many years had under consideration the action of blast pressure, but for a very long time was unable to investigate the distinctive action of quantity, apart from pressure, owing to the want of proper measuring apparatus. The advent of pneumatic tools and the wider adoption of compressed air has, however, lately led to much thought and research on the measurement of compressed air, and the results obtained by various investigators have been helpful in the design of an apparatus suitable for the experiments under consideration.

There are now many well-recognised methods of measuring the flow of air, and the following alternatives were carefully considered before making a final selection:—

(1). By Pitot tube readings of the average velocity in a pipe.

(2). By the pressure drop across a circular, sharp-edged orifice.

(3). By the pressure drop across a convergent nozzle.

(4) By the change of pressure between the entrance and throat of a Venturi tube, or convergent-divergent nozzle.

No. 1 has the advantage that very little special apparatus is necessary, the two Pitot tubes, with their pass-in glands and manometer gauge being all that is required to measure the velocity in any parallel portion of the air main, the true average velocity being obtained by correctly averaging the velocity found between the centre and the walls of the pipe. This method was used for the preliminary experiments, and the readings so obtained were very useful when designing the apparatus finally adopted. As the velocity in the air main was very low, the maximum pressure difference in the Pitot tubes was only from 0.9 in. to 1.1 in. water gauge. With this low head an error of 0.1 in. in reading the manometer gauge makes an error of 5 per cent. in the result. This uncertainty of accurate reading caused the Pitot tube method to be discarded in favour of one in which a greater pressure difference was obtained by increasing the velocity locally

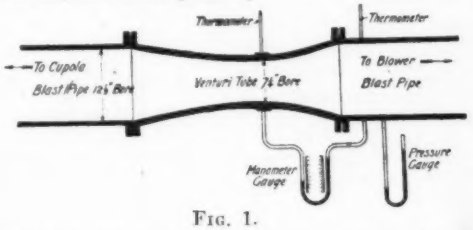


FIG. 1.

No. 2 is the most obvious way of increasing the velocity locally, but has the great disadvantage that the resulting pressure difference is almost entirely lost. Further, the simple formula for calculating flow through an orifice assumes that the fluid has free access to the orifice from all sides and that the velocity of approach is negligible. Where such conditions are not obtainable, a complicated and uncertain correction is necessary for velocity of approach. The necessity for such correction might have been avoided by considerably increasing the diameter of the blast pipe in which the orifice was to be fitted, but this alternative was considered too cumbersome and costly.

No. 3 has the disadvantages mentioned against No. 2, and was discarded for the same reasons.

No. 4 was the method finally adopted. It has the considerable advantage that the greater portion of the pressure drop which is utilised for measuring the velocity is recovered by the air before leaving the tube. For instance, with a pressure drop of 6 in. water between the entrance and the throat of the Venturi tube, the drop between the entrance and the exit was only about 1 in. water. In this case an error in reading the manometer gauge of 0.1 in. is only productive of an error *less* than 1 per cent. in the calculated volume of air passing. The proportions and arrangement of the apparatus used are shown in Fig. 1.

* British Foundrymen's Association Convention Paper.

The particular formula for calculating the flow of air through the Venturi tube illustrated is as follows:—

$$\text{Lbs. of air per minute} = 541 \times \frac{\sqrt{H \times P}}{T}$$

Where H = pressure difference between entrance and throat in inches water gauge, P = *absolute* pressure of air in pipe in lbs. per sq. in. (which takes into account the height of the barometer), and T = absolute temperature of air in pipe (deg. F.).

If it is desired to express the flow in cubic feet per minute the formula becomes:—

$$\text{Cubic feet per minute} = 200 \times \frac{\sqrt{H \times T}}{P}$$

Where H, T and P mean the same as before, and the volume is that occupied by the air at the pressure and temperature within the blast pipe.

The general formula for calculating flow through a Venturi tube and the first principles from which it is derived will be found in the appendix.

air below that to be obtained with the lowest speed of motor, the blower intake was throttled.

TABLE I.—*Particulars of Cupolas.*

	A	B
Cupola		
Diameter at melting zone	2′ 3″	3′ 6″
Area of tuyeres in sq. inches	94.4	91.2
A Z*	6	15
A T		
Height from top row of tuyeres to charging door sill	13′ 1″	13′ 4″
Number of tuyeres	8	7
Rows of tuyeres	2	2

* AZ = Area across cupola at melting zone.
AT = Total area of tuyeres.

After some preliminary investigations, it was decided to ascertain the maximum output of molten iron that could be obtained with varying conditions of blast. The routine observed was to start up the cupolas in the ordinary way and in half an hour or so after the blast had been put on—which was considered sufficient time to insure that the coke bed had reached the normal height—the blower was regulated to give the desired output of air, the cupola was emptied of all molten metal and the trial commenced. Every care was taken to insure comparative working, the metal was weighed to pounds, the coke measured, the stock kept up to the level of the cupola charging-door sill, and all tuyere sight-holes and slag-holes kept closed during the trials, which lasted from one half-hour to one hour each.

TABLE II.—*Summary of Tests.*

Test Number	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Cupola	A	A	A	A	A	B	B	B	B	B	B	B
Cubic feet of air per minute*	2,155	2,433	2,710	2,616	2,810	2,780	2,736	2,894.4	3,020	3,135	3,236	3,471
Height of barometer	30″	29.62″	29.33″	29.44″	29.8″	29.5″	29.8″	29.44″	29.3″	29.5″	29.4″	28.94″
Average lbs. of air per minute	171	192	214	206	227	222	221	231.5	242	255	267	285
Pressure of blast in ounces	9¼	10	11	14¼	15	10	11¼	14	14¼	15	16	18
Average of W × √P	526	606	710	784	880	702	750	866	922	987	1,069	1,210
Metal melted per hour	4 tons 8 cwts.	4 tons 18 cwts.	5 tons 5 cwts.	6 tons	5 tons 12 cwts.	5 tons 4 cwts.	6 tons 8 cwts.	7 tons	7 tons 12 cwts.	8 tons 10 cwts.	9 tons 8 cwts.	10 tons
Average composition of metal: Silicon	2.7%	throughout all the tests.										
Average composition of metal: Phosphorus	1.5%											
Coke used per 10 cwt. charge =	85 lbs.											
Average carbon in coke =	92%											
Lbs. of metal melted per minute per sq. ft. area of melting zone	41.2	45.9	49.2	56.3	52.5	20.17	24.83	27.1	29.5	32.98	36.3	38.66
Cubic feet* of air per ton of iron melted	29,386	29,780	30,970	26,160	30,106	33,000	25,560	24,806	23,760	22,080	20,640	20,820
Average value of lbs. of air × √pressure in ounces : tons of melted metal	119.5	123.8	127.2	118.3	157	135	117.1	123.8	121.3	116	113.6	121
Condition of metal	fairly hot.	hot.	very hot.	white hot.	not very hot at first, became very dull afterwards.	rather dull.	fairly hot.	hot.	hot.	very hot.	white hot.	hot at first, became dull afterwards.

* Volume measured at pressure and temperature existing in the blast pipe.
P = Pressure of blast in ounces.
W = lbs. of air per minute.

Readings of quantity and pressure of the blast were taken every 2½ minutes and the molten metal was measured in the same ladle for each test and independently checked by three persons. The whole of the metal melted during each trial was kept in the ladle before pouring. The summary of the results are given in Table II.

One of the outstanding features of these results is the regular working which ensued during each trial, the average of pressure multiplied by quantity practically equalling (and in some cases actually so) average pressure multiplied by average quantity. The

It may be observed here that the common practice of measuring air by volume is evidently less desirable than that of measuring it by weight, since the amount of oxygen available for combustion of the coke and melting of metal in a cupola is directly proportional to the weight of air supplied, but is only proportional to the volume after suitable corrections for pressure and temperature have been applied, which corrections will vary from day to day, if not from hour to hour. For this reason the measurements of quantity of air per minute have been considered in terms of weight throughout this Paper.

Two cupolas of the dimensions given in Table I. were available for experiments. It will be noticed that these not only vary in their diameters at the melting zone, but that the smaller one has a greater tuyere area than the larger. So if formulæ can be adduced to which these two very differently proportioned cupolas will conform, they might reasonably be considered correct for cupolas in general. Air was supplied by a "Piftin" type of rotary blower driven by a variable-speed electric motor. For outputs of

output given is the maximum which can be obtained over a short period. Over a fair afternoon's blow the large cupola gives within 10 per cent. of the maximum shown in Table II., and the small one within 15 per cent.

Mr. John Jermain Porter, late Professor of the University of Cincinnatti, U.S.A., in an article which appeared a short time ago in the "Engineering Magazine," stated that: "The maximum output of a cupola was obtained with 25 to 30 lbs. of air per sq. ft. area of melting zone." To this theory the large cupola approximated, but although the figures stated give a margin of 20 per cent., yet it is obvious they will not apply in the case of the small cupola, seeing that the minimum air supplied was 43 and the maximum 57 lbs. per sq. ft. area of melting zone.

The results of the trials with which this Paper deals were first set down graphically to the standard of lbs. of air supplied per minute, as shown in Fig. 2, when it was found that the spots did not conform to any regular curve. Also, during the trials it had been found that it was easily possible to get different outputs of metal melted with approximately the same quantity of air supplied but with varying pressure (see trials 6 and 7), the stock being more loosely packed in the cupola in the one case than the other, and thus offering less resistance to the air and reducing the pressure.

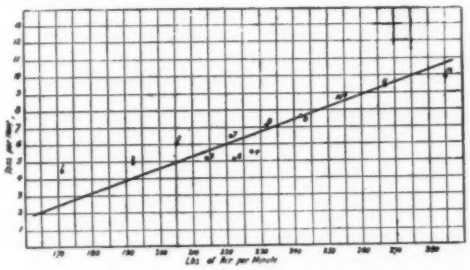


FIG. 2.
(*Figures Correspond to the Numbers of the Trials in Table II.*)

Dr. Moldenke, in a recent article, shows that the melting zone in a cupola is probably around an inverted cone, with which the author agrees. The proportions of this cone will necessarily be dependent upon the penetrating influence and velocity of the blast due to its pressure as well as to the quantity of air. If, therefore, pressure and quantity are both dominating factors, any theory that leaves out one or the other is not based on sound principles.

The results of the tests were next set down graphically in terms of lbs. of air per minute multiplied by $\sqrt{}$ pressure of air in ounces, when all the result were found to be so consistently close to a straight line diagram (see Fig. 3) that there are good grounds for assuming that this method of calculating the ratio of air to metal melted is quite sound and correct in practice. It is to be noted that $\sqrt{P.}$ is a measure of the mean velocity of the air through the cupola. The points plotted in Figs. 2 and 3 are taken from both the cupolas under test, as will be seen, and the point in the middle of the series in Fig. 3 which lies some way below the straight line, is actually that corresponding to the extreme range of the smaller cupola. It must not be objected that this point does not confirm well to the straight line law, for in this case the amount of air introduced was excessive, being so great as to introduce serious oxidation of the metal. Test No. 12 showed signs of oxidation by the brown colour of the gases given off at the top of the cupola, while test No. 5 showed very excessive oxidation to be taking place, which accounts for the reduced output.

As may be expected, there is a limit to the rate of output of any cupola, and it is excessive oxidation which will in general set this limit. Again a comparison of the dimensions and results obtained with the two cupolas from which the points on Fig. 3 were plotted shows that the maximum weights of iron per hour which could be melted were approximately proportional to the *diameters* of the melting zones. These conclusions may be combined into two quite simple laws, as follows:—

(1). That the output of any cupola up to its maximum value in tons per hour is equal to the product of the air supplied in lbs. per minute multiplied by the $\sqrt{}$ pressure of the air in ounces and divided by 120.

(2). That the maximum possible rate of successful output will be obtained when the $\sqrt{}$ pressure of the blast in ounces multiplied by the quantity of blast

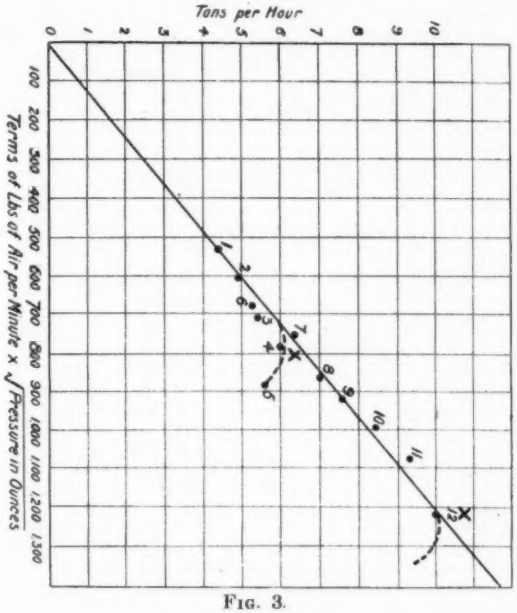


FIG. 3.

(*Figures Correspond to the Numbers of the Trials in Table II.*)

in lbs. per minute divided by diameter of melting zone in feet = 330.

$$\frac{W \sqrt{P.}}{D} = 330$$

When P = gauge pressure of air in ounces, W = quantity of air in lbs. per minute, and D = diameter of melting zone in feet.

The points corresponding to this formula for the two cupolas under consideration are marked X on Fig. 3.

In addition to the blast pressure, as distinct from quantity, having an effect upon the melting ratio in a cupola, it also has a large bearing on the quality of the metal produced. The author some time ago undertook some experiments to ascertain the effect of blast pressure upon the metal melted.* These ex-

* See South Staffordshire Iron and Steel Institution Proceedings, 1910.

periments were made in a small experimental cupola and with small tuyeres; every care was taken to ensure similar conditions—with the exception of pressure—in each test. The tuyeres were made up to the same size each time with ganister, and the pressure was kept under complete control by means of screw-down valves. Several kinds of pig-iron were investigated, and Fig. 4 is typical of the resultant diagram. This figure shows the hardness of the metal to increase directly as the blast pressure, the ordinates practically falling on a straight line. The transverse and tensile results show an increase in strength along with hardness up to a point, after which a decrease occurs. This diagram is characteristic of all the irons experimented with, except in one point, namely, that for the iron to which the curves plotted in Fig. 4 applies, which was ordinary No. 3 pig, the peaks in both the transverse and tensile test curves occur at the same blast pressure and hardness; but as the irons experimented with belong more to the harder class, so did the peaks of the two curves become more divided, the peak of the transverse curve in the harder class of metal being associated with rather lower hardness and blast pressure than that which gave the highest tensile results. The alteration in chemical composition in the series of tests under consideration was as follows:—Total carbon decreased from 3.4 per cent. to 3.12 per cent. practically in even stages; combined carbon, of which

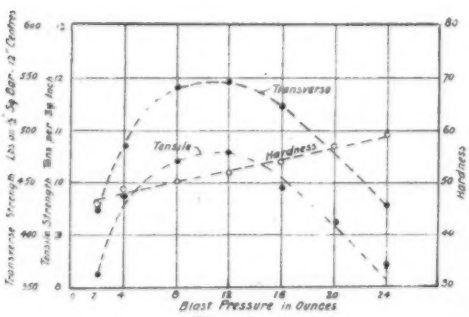


FIG. 4.

there was only a faint trace in the original pig-iron, showed no perceptable increase up to 12 ounce blast pressure, then increased to 0.10 per cent. at 16 ounce, 0.16 per cent. at 20 ounce, and 0.26 per cent. at .. ounce pressure. Sulphur increased from 0.01 per cent. to 0.043 per cent., practically the same increase being shown in each test. Phosphorus and manganese remained normal throughout, and silicon, of which the original pig contained 3.26 per cent., was rather erratic, showing no regular tendency to increase or decrease. Although the tests were taken under exceptional conditions, and would necessarily vary with different types of cupola and metal melted, yet the tendency would be in the direction indicated in this particular case.

As pressure has been shown to be of much importance, it necessarily follows that the size of the tuyeres (on which pressure so largely depends) should receive careful consideration, and it is the author's opinion that, where the castings are required to have the maximum softness, the total area of the tuyeres should not be over 1/6th the area of the melting zone. For general engineering work, which is usually much heavier than the former, and where iron closer in texture is desired, the tuyere area should be about 1/9th the area of melting zone, and for steam and gas-engine cylinder and similar work the total tuyere area should be from 1/12th to 1/16th the area across the melting zone.

The height of the cupola from the top of the tuyeres to the charging-door sill appears to also have a bearing on the efficiency of the cupola. The results of a great many particulars published in the technical press, have shown that where this dimension has been *not less* than 2½ to three times the diameter across the melting zone, the cupolas have given much better results than in cases where the dimension has been less.

An item of very great importance in the economical working of a cupola is the quality and quantity of coke used. Probably Mr. Jermain Porter has done more work* on the thermo efficiency of coke in the cupola than anyone else, and in the article previously referred to he states that with coke containing 90 per cent. of carbon the consumption subsequent to the bed with well designed and economically worked cupolas should not exceed 0.09 lbs. per lb. of metal melted. In the experiments under consideration the average composition of the coke was 92 per cent. carbon, and the consumption was 0.075 lbs. per lb. of iron melted.

Summary.

The author's opinions and experience, together with the results of the tests given, lead him to the following conclusions:—

(1). That both pressure and quantity of blast have to be considered in cupola working.

(2). That an average of 120—in terms of quantity of air in lbs., multiplied by √pressure in ounces—is required to melt one ton of ordinary phosphoric iron.

(3) That the maximum output of metal melted per hour is more nearly comparative to diameters of cupolas than areas of same. (This also appears to be borne out by the remarks of Dr. Moldenke in the "Foundry," December, 1912.)

(4) That the maximum output of a cupola will be obtained when the pressure and quantity of the blast in ozs. and lbs. per minute respectively, are so adjusted that $\frac{W\sqrt{P}}{D} = 330$, D being the diameter of the melting zone in feet.

(4a) That any further increase in the product $W\sqrt{P}$ beyond that determined in conclusion (4), results in excessive oxidation of the metal in the cupola.

(5) That iron melted in a cupola is affected in hardness directly as the pressure of blast used.

(6) That in consequence of (5) the total area of the tuyeres employed should be regulated according to the class of iron being melted, small areas being used when greater hardness is required.

(7) That the height of the cupola, from the top tuyeres to the charging-door sill should *not be less* than two and a half to three times the diameter across the melting zone.

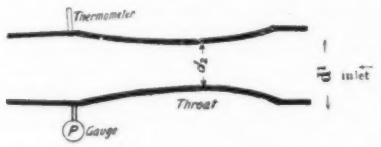
(8) That the coke consumption in a well-designed cupola need not be more than 0.075 to 0.09 lbs. per lb. of ordinary phosphoric iron melted, when the coke contains from 90 to 92 per cent. of carbon.

In conclusion, the best thanks of the author are due, and are hereby accorded, to Mr. J. M. Walshe, A.M.I.E.E., for his valuable assistance with the formulae and design of apparatus used, without which the author could not have undertaken the work; to Mr. R. A. Hayes, M.A., for assistance in several directions, and to Messrs. Belliss & Morcom, Limited, for allowing the results to be published.

* See Report of Eighth International Congress of Applied Chemistry, Vol. 5.

Appendix.

Calculation of the flow of air through a Venturi tube.



Let the changes of pressure in the air as it flows through the tube be so small that the density may be taken as constant = w lbs. per cub. ft.

Let P_1 and P_2 be the pressures in lbs. per sq. ft. at the inlet end and throat of the tube respectively
" V_1 and V_2 " " velocities in ft. per sec.
" A_1 and A_2 " " areas of section of tube in sq. ft.
" d_1 and d_2 " " dias. of section of tube in ft.

Then the volume of 1 lb. of air $= \frac{1}{w}$ cubic ft. and hence the work done in pushing 1 lb. of air from the inlet end to the throat $= \frac{P_1 - P_2}{w}$ ft. lbs.

This work all goes to increase kinetic energy

$$\therefore \frac{V_2^2}{2g} - \frac{V_1^2}{2g} = \frac{P_1 - P_2}{w} \text{ or } V_2^2 - V_1^2$$

$$= \frac{2g}{w}(P_1 - P_2). \quad - - - a.$$

But since the density of the air is practically unaltered (as has been assumed) $\therefore \frac{V_1}{V_2} = \frac{A_2}{A_1} = \frac{d_2^2}{d_1^2}$

$$\therefore V_2^2 = V_1^2 \frac{d_1^4}{d_2^4} \therefore V_1^2 \left(\frac{d_1^4}{d_2^4} - 1\right)$$

$$= \frac{2g}{w}(P_1 - P_2) \quad - - \text{from } a.$$

$$\text{or } V^1 = \frac{d_2^2}{\sqrt{d_1^4 - d_2^4}} \sqrt{\frac{2}{w}(P_1 - P_2)}$$

Now the cubic ft. of air per sec. flowing into the tube $= V^1 A_1$. Hence the weight of air per second $= V_1 A_1 W$ lbs.

Hence flow of air $= 4 \frac{\pi d_1^2 d_2^2}{\sqrt{d_1^4 - d_2^4}} \times \sqrt{2 g w (P_1 - P_2)}$ lbs. per sec.

If $(P_1 - P_2)$ be expressed in inches of water head, and d_1 and d_2 be measured in inches, the formula gives

$$\frac{\pi}{4} \times 144 \times \sqrt{\frac{2 \times 32.2 \times 62.4}{12}} \times \frac{d_1^2 d_2^2}{\sqrt{d_1^4 - d_2^4}} \sqrt{h w}$$

$$= .1 \frac{d_1^2 d_2^2}{\sqrt{d_1^4 - d_2^4}} \sqrt{h w} \text{ lbs. per sec.}$$

Lastly, since 1 cubic ft. of air has a weight of $\frac{144 P}{53 T}$ lbs. where P is its absolute pressure in lbs. per square inch, and T is its absolute temperature in ° F, the above formula may be conveniently expressed in the form

$$\text{Flow of air} = .1 \times \sqrt{\frac{144}{53}} \frac{d_1^2 d_2^2}{\sqrt{d_1^4 - d_2^4}} \sqrt{\frac{P h}{T}} \text{ lbs. per sec.}$$

$$= .162 \frac{d_1^2 d_2^2}{\sqrt{d_1^4 - d_2^4}} \sqrt{\frac{P h}{T}} \text{ lbs. per sec.}$$

d_1 and d_2 being in inches.
h in inches head of water.
P in lbs. per square inch absolute.
T in F. deg. absolute.

Hints for Young Patternmakers.

Every new job is a new problem, but principles do not alter, although applications may differ.

Quickness in pattern-making is measured *not* by time alone, but also by skill and accuracy.

A pattern's value is always comparative, the initial cost being relative to the value of the castings produced.

Know when, where and how to split or divide a pattern. It means all the difference between a serviceable and unserviceable tool.

Split or divided patterns should be well varnished on their joints. They will probably be more exposed to moisture (from the moulder's "swab") than any other portion of your pattern.

Taper is like charity; be as liberal as you can afford.

Excessive taper should be accounted for in the core-box or strickle.

Be generous, almost extravagant—consistent with reason—in the taper given for deep top prints. This also applies to bottom prints of deep pattern lifts.

In the taper given for the pattern and core-box for the same job, exercise judgment and be sure that you do not rob one at the expense of the other.

There is no definite taper allowance. The limit of taper must be governed by the casting design and its uses.

For accurate core work don't leave the taper for the core-maker or moulder to "rub off." His methods for doing this are as unsatisfactory as the tools he uses for this purpose. "Carding" or rasp files are not conducive to accurate workmanship.

If a portion of a pattern can be "worked" loose and is easily "get-at-able," it is preferable in every way to a drawback or false core.

Skewers for "holding" loose pieces in position should be easy, accurate fitments. If they fit too loosely they are questionable blessings, or if too tightly they are a curse, and the cause of many.

Screws are to be preferred to skewers for attaching loose pieces, assuming that every facility is given for their removal.

Skewers usually only define, but do not retain loose pieces into position. Screws both define and retain in position, but their uses are limited by their accessibility.

Round-headed screws are more suitable than the countersunk variety for loose pieces. Their heads being visible, require no "searching" for the socket for their detachment.

If dovetails can be utilised for loose pieces they are to be preferred to either screws or skewers, as during the ramming up of the mould no disturbing influences take place, such as the removal of these latter.

The use of dovetails being conditional, they must be true, accurate fitments, and to be so for repeat jobs, should be made of metal both tail and socket.

Wood dovetails are always questionable. They are very liable to shrink, warp, and expand owing to the moisture and the varying temperatures to which they are subjected.

Rapping plates are necessities, not luxuries. To omit them is to reduce the value of your work.

The position of a rapping plate's rapping hole is that point which, directed upon by force, is most susceptible to vibration caused by the force impact.

Rapping plates in their right positions prolong the "life" of a pattern and therefore increase its value.

A rapping plate in a wrong position is only a queer, useless form of ornamentation.

Semi-Steel.*

By M. Riddell.

Ironfounders have for long been impressed with the limitations of cast iron, caused by the nature and quantity of the various elements which are inevitably associated in that product. This impression becomes accentuated by the knowledge that steel, which exhibits such superior mechanical qualities, is really a purified or refined cast iron. Various suggestions for improving the qualities of the metal by introducing other ingredients into its constitution have, from time to time, been proposed. Prof. Turner mentions that the "physics" described with this object in view have ranged from tin to tobacco juice.

The method in which we are particularly interested at present, is that of casting from mixtures of pig-iron and steel in varying proportions, the product beng known by the somewhat euphonious title of "Semi-steel." The choice of name is rather unfortunate, because the casting produced possesses none of the special virtues which we associate with steel. It lacks ductility and can be neither forged nor welded. The utmost that can be claimed for the mixture is that it is a superior form of cast iron.

Concerning the process itself and the benefits which are claimed to be conferred upon the casting, there is, in this country at least, considerable diversity of opinion. The difficulties connected with the melting of steel in the cupola and the prevalence of hard spots and sponginess appear to some as insurmountable. It is these difficulties which this Paper proposes to investigate, in the hope that the theories and explanations offered may be of some service to others in overcoming their troubles with semi-steel.

The notion that castings could be improved in their mechanical properties by mixing wrought iron, which may be considered to be a very mild steel, or steel itself with pig-iron is by no means a new one. So far back as 1846 we find in the records of the Patent Office that a Mr. Sterling took out several patents for a method of toughening cast iron by melting wrought scrap and pig-iron together. He claimed that with 10 per cent. wrought scrap he got an increase of 10 per cent. in the strength of the casting, with 20 per cent. the increased strength was 30 per cent., and with 30 per cent. the improvement in the strength was 60 per cent. The last figures represent the maximum improvement claimed by Sterling for his process, as he states that with greater percentages of scrap, the strength of the casting was found to decline. With regard to practical working of the process he makes the significant statement, that the improvement depended very largely on the nature of the pig-iron and that some brands proved more suitable than others.

The difficulty of fixing on the suitable brands of iron, along with the inevitable difficulty of melting and casting sound castings from such mixtures, are doubtless responsible for the method not having been commercially pursued.

Sterling's method of preparing the mixture involved the placing of wrought iron in the pig beds and casting the pig-iron round it. His idea was that both metals would melt and come down together in the cupola, thereby producing a homogeneous result.

* British Foundrymen's Association Convention Paper.

In America the increasing shortage in the supplies of cold-blast irons caused the ironfounders there, and especially those who were interested in the manufacture of rolling-mill rolls, pinions, car wheels and such like, to direct their attention to the finding of a substitute. Through perseverance and close attention to details the casting of so-called semi-steel mixtures has become an important and integral part of the American foundry business. It is common practice in a great many machinery and jobbing shops, while several of the largest foundries adopt the method entirely for all their castings.

At first much difficulty was experienced in getting homogeneous metal on account of the steel not mixing or entering evenly into combination with the iron. To overcome this difficulty various expedients were adopted, such as Sterling's method of casting pig-iron round the steel and also that of melting pig-iron and steel scrap together and casting into pigs to be remelted for the final casting, as is sometimes done with ordinary pig-iron mixtures.

In American foundries, chemical analysis plays an important part in the regulation of cupola mixtures and there is no doubt that a large part of their success with semi-steel is due to this fact. A knowledge of the materials at our disposal, as well as of their physical and other properties and their behaviour in the cupola, is of immense assistance in obtaining regular and satisfactory results. In the case of semi-steel mixtures such knowledge is indispensible for reliable and satisfactory working.

All the metalloids which are found in pig-iron are, in the case of steel, regarded as impurities. As is well known, the process of steel-making consists in first practically eliminating these impurities and thereafter adding predetermined quantities of such as are necessary to give the metal the character desired. When dealing with cast iron, we must take the impurities as we find them, and endeavour by suitable mixing to keep them within bounds for the work in hand. The weakness and shortcomings of cast iron arise from the excess of most of these metalloids, although, at the same time, their presence imparts to the metal properties which make it peculiarly suitable for casting purposes.

Carbon is the most important of all the metalloids, as the quality and usefulness of the metal for any purpose is primarily determined by the quantity as well as by the form of the carbon present. The proper regulation and control of this element is the most serious problem the semi-steel melter has to solve. If there were no reactions in the cupola, matters would be much simplified and the results could be forecast with a fair amount of accuracy.

Melting Difficulties.

As is well known, pure iron is fusible only at very high temperatures. One effect of adding carbon to pure iron is to lower the temperature at which the metal begins to melt. The more carbon that an iron contains the more readily is it melted. Shortly expressed, it may be said that the melting point is a function of the percentage of carbon present. By referring to the equilibrium or freezing curve diagram (Fig. 1) it is possible to determine the fusion point at any grade of iron-carbon alloy. In the case of cast iron the other constituents, and

especially the phosphorus, assist in lowering the point at which melting begins.

Taking the upper portion of the diagram, we see that the temperature required to melt alloys with over 2 per cent. carbon is about 1,150 deg. C. If a 1.00 per cent. carbon steel is used a temperature of over 1,300 deg. C. is required before melting begins, and if the scrap consists of steel rails with 0.30 per cent. or boiler plate with 0.16 per cent. carbon, the initial fusion points are proportionately raised. These figures indicate approximately the temperatures shown on the diagram, but as recent research has imposed some modification in the shape of the curve, they are to be taken in the present instance as only illustrating a principle.

Most of the steel scrap which is used in semi-steel mixtures consists of low-carbon metal, such as steel rails or boiler plate. When it is considered that the very high temperatures necessary to melt this material are not usually attained in cupola practice, it is easy to see that, at the very outset, the process is confronted with a difficulty.

Notwithstanding its infusibility at cupola temperatures, steel scrap is reduced to the molten condition in the cupola, and it is the more necessary that the semi-steel melter should have some theory regarding the influences at work to render steel fusible, if he is to run his practice on scientific lines.

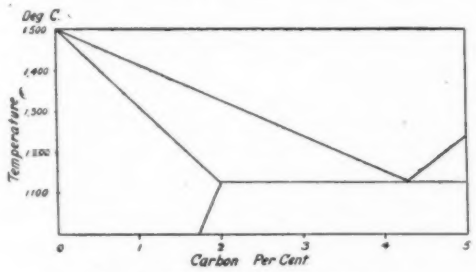


FIG. 1.—EQUILIBRIUM DIAGRAM.

It has been suggested to the writer as a possible solution of the melting difficulty, that the iron and steel act with respect to each other as do the constituents of an alloy, and that the melting temperature is reduced in virtue of the alloy principle when the constituents are brought into contact. This explanation is not altogether satisfactory. The two metals do not form an alloy as the term is generally understood. An alloy is an intimate mixture of two or more distinct elements, such as silver and copper or iron and carbon, and which at certain points of concentration form eutectics. Cast iron and steel are only modifications of the same alloy, and they do not form an eutectic. Further, any one who has seen how the melted pig-iron trickles down through the coke in more or less restricted and defined channels will appreciate that it would take a very large quantity of pig-iron to effectively reduce a comparatively small quantity of steel.

The theory which the writer offers is based on the affinity and absorptive power of iron for carbon taken in conjunction with the information shown on the equilibrium diagram.

Under the conditions which prevail in the blast furnace, iron can absorb or dissolve fully 4.00 per cent. of carbon. The actual amount which will be dissolved is simply a question of time and temperature. It is for this reason that cold-blast irons contain less carbon than hot-blast pig-irons. Steel is a cast iron from which this absorbed carbon has been largely removed, and, when we introduce it into the cupola among carburising influences, it will set about to recover from its surroundings some of the carbon of which it has been deprived. The coke, the carbon monoxide gas, and even the pig-iron itself will be called upon to furnish their share of carbon. It is not necessary for the iron to be in the molten condition before it can absorb the carbon. The action begins soon after the metal is at a good red heat. It is this principle which is the basis of the cementation process of steel-making.

It has already been pointed out that the melting temperature is determined by the amount of carbon present in the iron. What happens, therefore, in the cupola is, that the steel absorbs carbon, as above indicated, until it contains the percentage necessary for the temperature of the cupola at the time. When this point is reached, the steel may be said to be saturated with carbon and the slightest increase in either the carbon or the temperature will make it liquid. For example, if the temperature of the cupola is 1,300 deg. C. and the steel scrap consists of boiler plate with 0.16 per cent. carbon, this will remain solid and continue to absorb carbon until there is 1 per cent. present, and whatever part of it contains that amount of carbon becomes fusible at that temperature. With a higher temperature less carbon will be required and with a lower temperature more carbon will be taken up before the metal is fusible. It is questionable if a temperature of even 1,300 deg. C is reached in general cupola practice.

It should also be noted that the absorption of carbon continues after melting, and while the steel is in contact with the coke, etc. The action is a surface one. The outside of the steel becomes saturated first, and as this melts off fresh surfaces are exposed to the carburising influences. It follows from this fact that the greater surface a given weight of metal can expose to these influences, the more quickly will the melting take place. Thick, chunky pieces of steel will require a considerable time for all the metal to take up the necessary carbon and it is possible for such pieces to be carried down to the bottom of the cupola before their melting has been completed. When this happens the still undissolved steel continues to absorb carbon from the surrounding molten metal as well as from the coke. With massive pieces of steel there is the danger of the metal not being completely dissolved during the run of the cupola, and some interesting and expensive work may have to be undertaken before the cupola is put in use again.

The melting of pig-iron presents a different aspect. In pig or cast iron the phosphide eutectic is the last to solidify, and this it does at the comparatively low temperature of about 950 deg. C. While some of the phosphide gets entangled among the crystals which have formed out earlier, it becomes more segregated towards the centre of the pig or casting. When the pig iron is put into the cupola the centre is the first to liquify, and by the time the outer portions have reached the melting point of cast iron the whole mass is ready to collapse.

It is evident, therefore, that the reduction of pig iron to the liquid condition proceeds on entirely opposite lines to that of steel, the one melting from the inside outwards and the other from the outside inwards. By the time the mixture has reached the temperature of the melting zone, it may be said that the pig-iron has finished melting, whereas the steel scrap is only beginning to dissolve. The outside of the latter is the only part which is meltable, and therefore the more outside with the less inside the steel has, the more nearly will its speed of melting approximate that of the pig iron.

When steel scrap is added in the ladle, the carbon which is necessary for fusion at the temperature of molten iron will be taken from the surrounding cast iron. To demonstrate that this is what actually takes place, and at the same time to gain some insight into the melting phenomena of semi-steel mixtures, it is only necessary to examine a piece of soft iron or steel rod which has been used in the cupola spout. If the rod be broken at a part where it has been in contact with the running iron, the fracture will show the soft grey iron centre surrounded by a narrow band of close-grained high-carbon steel. The rod appears as if it had been chilled or case-hardened and a trial with a file will confirm this impression. The carbon in this case could come only from the cast iron, and any portion of the rod which had been dissolved off must have contained about 2.00 per cent. of carbon, the amount necessary, according to the diagram, at the temperature of molten cast iron.

The photograph (Fig. 2) taken from the section of a tapping rod which had a globule of phosphoric cast iron attached, shows the cementation process very distinctly. Below the cast iron with its phosphide spicules, the edge of the rod is seen with a fair percentage of free cementite, indicating high carbon content. Between the edge and the centre of soft grey iron there is a band of pearlite which

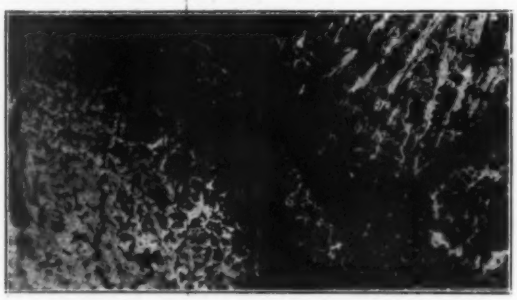


FIG. 2.—TAPPING ROD. MAG., 100 DIAM.

would contain about 0.90 per cent. carbon. The original diameter of the rod was $\frac{1}{2}$ in., and the section was taken through a portion which had been reduced to $\frac{3}{8}$ in. in the spout. This specimen contains in a nutshell, as it were, the whole history of semi-steel. It shows not only the gradual saturation of the steel and the purely surface action in dissolving, but throws some light on the origin of hard spots in semi-steel castings.

Among the benefits expected from the use of steel in the cupola is that there will be a corresponding reduction in the percentage of total carbon in the casting. So far as cupola mixtures are concerned, the foregoing considerations show that this expectation cannot be fully realised. In practice it will be found that the difference between the percentage of carbon in the pig-iron and that in the final casting will be but slightly, if any. Thus, in a 20 per cent. semi-steel mixture, using a 3.50 per cent. total carbon pig-iron and a 0.16 steel scrap, there should be, apart from any reactions in the cupola, only 2.83 per cent. of carbon in the casting. The results of a number of analyses with various percentage cupola mixtures show that the steel absorbs sufficient carbon to bring its own carbon content up to somewhere about 2.00 per cent. It may be slightly less or more. Instead of 2.83 per cent. carbon, it will be found that the casting contains nearly 3.20 per cent.

There is, therefore, no advantage to be gained by the use of low-carbon steel scrap in the cupola, but rather the reverse. No matter what percentage the steel contains originally, it must attain the percentage to bring it into equilibrium with the temperature of the cupola before it will melt at all. The less carbon it has to begin with the longer will it take to reach the saturation point. The most important point for the semi-steel melter to consider is the size and section of the scrap. The cupola will look after the carbon. Hot and fast melting with the metal cleared from the cupola as quickly as possible to remove it from the coke is, of course, desirable.

The percentage of total carbon in a casting from a ladle mixture will be reduced, the reduction depending on the proportions of iron and scrap which are used, and their relative carbon contents. For obvious reasons the amount of scrap which can be added in the ladle is small. There is no gain in carbon, and a mild steel will give a greater reduction than a high-carbon steel from the same proportions of scrap and iron. As the temperature falls rapidly, only the thinnest of scrap should be used in the ladle.

Another element which calls for consideration in semi-steel mixtures is the silicon. This substance derives its importance from the influence it exercises over the form of the carbon in cast iron. In steels all the carbon is in the combined form and silicon is not desired in that metal. If found at all, it is only in traces. In passing through the cupola there is a slight loss in the silicon of the pig-iron. Assuming, for the sake of simplicity, that this loss is compensated for by the silicon in the steel, a mixture with 20 per cent. scrap as before, and a 2.00 silicon pig will give a percentage of 1.60 silicon in the casting. With practically no alteration in the carbon, this reduction in the amount of the silicon will result in a larger percentage of the carbon being in the combined form and thus tend to make the casting hard and brittle.

Close attention requires to be paid to this reduction and provision made for the silicon in the casting being brought up to an amount compatible with the work in hand. It is recommended that for light castings of a light section, especially if they are to be machined, that the silicon should be nearly 2 per cent. Heavier castings will do with less.

The other constituents of cast iron, with the exception of manganese, demand only a passing reference. The behaviour and influence of sulphur is the same in semi-steel mixtures as in ordinary mixtures of cast iron. There is this advantage from a semi-steel mixture that the percentage of these impurities is thereby reduced.

The remarks about manganese will be incorporated with what is to be said concerning the objections which many strongly urge against the use of steel scrap, namely, hard spots and blow holes.

Hard Spots.

While hard spots and blowholes are not uncommon in semi-steel castings their presence is due not so much to any fault of the process itself as to a failure to understand the conditions which govern the process.

The explanation which is generally given to account for the presence of hard spots in semi-steel castings is that these are caused by imperfectly melted steel, implying that the temperature in the cupola was not high enough to melt it thoroughly. One of the Papers presented at the Conference in Glasgow two years ago contained some interesting observations on this subject. The writer of the Paper stated, *inter alia*, that when steel scrap, such as punchings, was

used, there was a chance of some of the punchings getting to the bottom of the cupola through the coke. Once they got so far there was not heat enough to melt them way. These incompletely melted punchings he believed were the cause of hard spots. Considering the composition of such scrap, it would appear more natural, however, to expect that the spots would be soft instead of being hard if imperfect melting was the only explanation. As has already been pointed out, it is possible to melt or dissolve steel scrap in the ladle where the temperature is even lower than in the cupola.

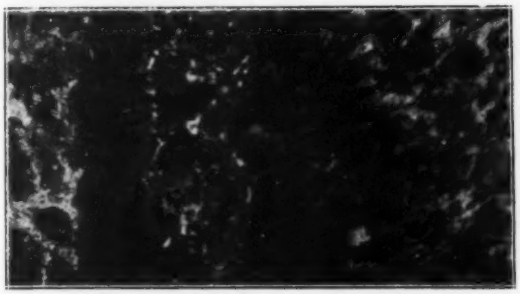


FIG. 3.—MILD STEEL IN CAST IRON.

The true explanation is to be found, not in imperfect melting, but in imperfect mixing after the metal has been melted. It is merely a question of getting the carbon and silicon evenly distributed throughout the mass. A simple illustration showing how a hard spot can be manufactured will probably make this quite clear. We have only to imagine a small piece of a soft iron or steel rod placed in a ladle of good hot iron and allowed to lie there without being disturbed. As soon as the temperature of the piece gets high enough it will begin to absorb carbon from the iron. When at the temperature of

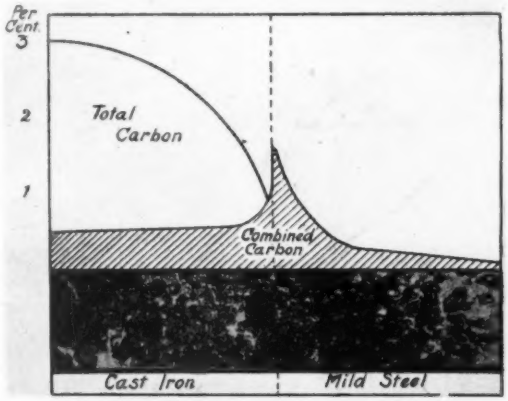


FIG. 4.—DIAGRAM OF CARBON IN CAST IRON AND MILD STEEL.

the liquid cast iron, it will continue to absorb carbon until it contains nearly 2 per cent. It will take up no silicon at all, and consequently, if the metal is allowed to solidify without being disturbed, a spot will be found in the casting with a high percentage of combined carbon. The obvious remedy was to have stirred the metal until the melted spot had been completely diffused in the surrounding iron.

Any pieces of steel scrap which reach the bottom of the cupola in the solid condition will complete the melting by absorbing carbon from the coke and iron lying in the bed. In doing so they will form segregations of high carbon but siliconless liquid metal and when the cupola is tapped these segregations will be only partially broken up, with the result that they will appear as hard spots in the castings.

Fig. 3 shows a piece of very soft iron which has been surrounded with cast iron in the mould being transformed into a hard spot. As in the case of the tapping rod, the change from ferrite into cementite, representing the extremes of the iron carbon alloys in the matter of hardness, is clearly seen. While in a specimen so prepared, the cementite has not developed much beyond the edge of the soft iron the process would have continued until the whole of the soft metal had been converted if the heat could have been retained as it is in the bottom of the cupola. A peculiar feature to be noticed is that the phosphide eutectic appears to have been pushed back into the cast iron.

The diagram (Fig. 4) is a rough attempt to indicate the manner in which the carbon progresses from

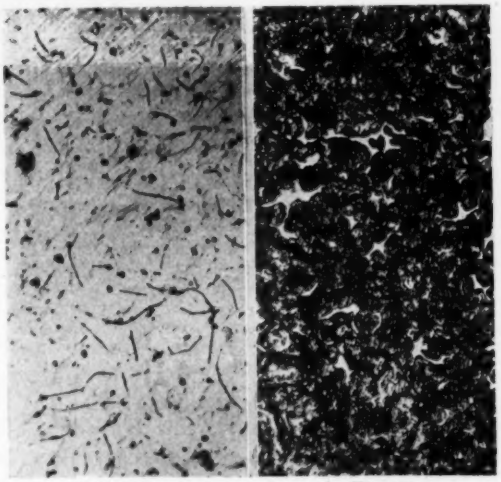


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FIG. 5.—HEMATITE. MAG., 100 DIAM.

a high to a low carbon iron. The total carbon appears to diminish in the vicinity of the junction of the two metals. The combined carbon, which is just over 0.5 per cent. in the cast iron, rises to nearly 0.9 per cent. At the point where the cast iron and steel meet there is a sudden rise in combined carbon to about 1.6 per cent. Thereafter the curve falls until it reaches the level of the carbon in the steel. The slope of the latter part of the curve will depend on the length of time the temperature has been high enough to allow the transition to take place.

Blowholes.

The blowholes referred to, are derived from the gases dissolved in the iron. At high temperatures iron has considerable solvent power for oxygen, etc. As the metal cools the solvent power is reduced and the dissolved gases are gradually thrown out. If the evolution is continued while the iron is becoming pasty, the gases are trapped and blowholes result. Steel castings are particularly liable to develop such holes, and to obviate them as far as possible, some deoxidising agent is generally introduced. Man-

ganese and silicon have each considerable affinity for oxygen and they also increase the power of the iron to hold the gases in solution at lower temperatures. With suitable proportions of either, the gases may be retained in solution until the iron has solidified.

The blowholes found in semi-steel are caused largely if not altogether, through imperfect mixing. In a great many cases the manganese present in the

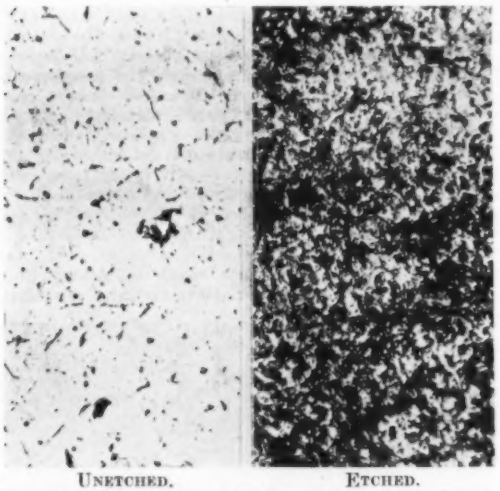

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FIG. 6.—HEMATITE AND 25 PER CENT. STEEL SCRAP. MAG., 100 DIAM.

pig-iron is sufficient to act as a deoxidiser if the metals are properly diffused through each other. On the other hand, if they are not so diffused, patches will be found where both silicon and manganese may be conspicuous by their absence. While these patches are solidifying, which they will do before the last of

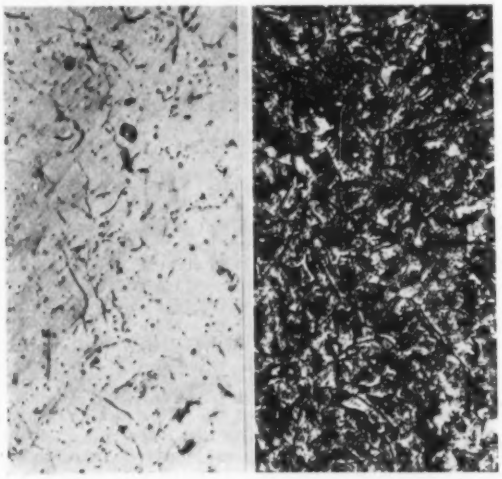

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FIG. 7.—GENERAL AND JOBBING MIXTURE. MAG., 100 DIAM.

the cast iron, gases may be evolved and find their way into the surrounding liquid.

To prevent these gas holes many workers, following the steel practice, add a small amount of ferro-manganese to the semi-steel mixture. This practice is probably induced by the fact that steel is being used, but since the casting when properly mixed consists of cast iron only, an indiscriminate resort to manganese is not to be recommended. The reason why ferro-manganese is used in preference to ferro-silicon in steel working is because of the different effect these have on the carbon. In

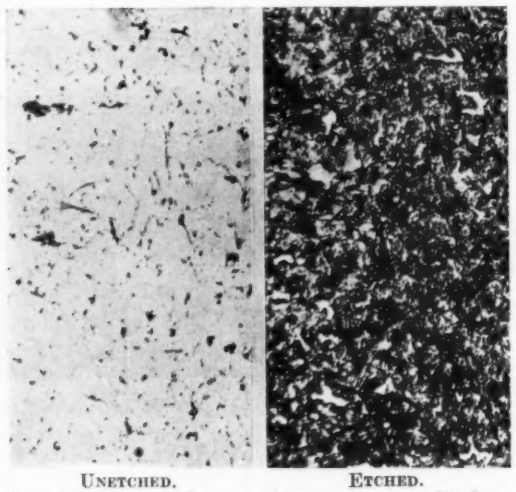

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FIG. 8.—GENERAL JOBBING MIXTURE, WITH 25 PER CENT. OF STEEL SCRAP. MAG., 100 DIAM.

steel all the carbon is desired in the combined form. Manganese facilitates the formation of combined carbon, whereas silicon has the opposite effect.

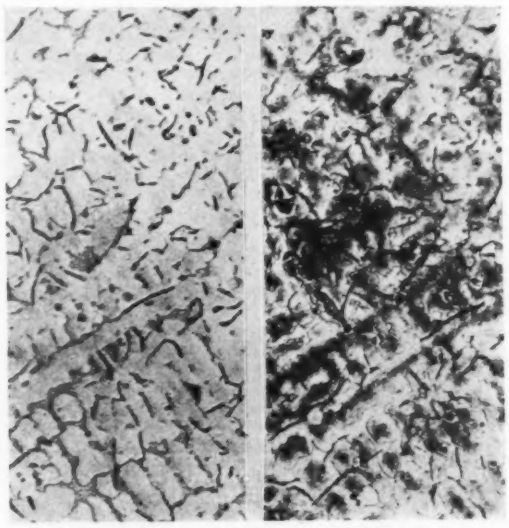

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FIG. 9.—HARD MIXTURE; NO. 4 FOUNDRY IRON, 20 PER CENT.; GENERAL SCRAP, 20 PER CENT.; HARD SCRAP, 45 PER CENT.; AND STEEL SCRAP, 15 PER CENT. MAG., 100 DIAM.

In semi-steel mixtures, as has been pointed out, the carbon percentage is little altered, while the

silicon is reduced according to the proportions of steel and iron which have been used. This results in an increase in the percentage of combined carbon in the casting. The addition of manganese will still further increase the amount and may thereby produce a casting which will be extremely hard and difficult to work. By adding silicon, the double function of regulating the carbon and disposing of the blowholes can be performed. The addition of either of these agents, will fail, however, in accomplishing its object if the mixing of the whole is not complete.

In this connection the importance of hot working cannot be too strongly emphasised. Not only does the heat in the cupola lessen the demand of the steel for carbon, but in producing hot metal it thereby facilitates the proper mixing of the ingredients.

It has been found in practice that the process is aided by having the cupola and charge well heated up before the blast is turned on. By increasing somewhat the height of the bed and placing the steel scrap on the top of this, an opportunity is afforded for the steel to soak in carbon in preparation for the melting proper. Kirk in his recent book on "Foundry Irons" records the experience of an American founder when melting a high ratio steel mixture. On one occasion, owing to some trouble or other, it was found necessary to stop the melt for some minutes. When the blast was turned on again the founder was surprised to find that his metal came down quicker than it had ever done before. The explanation given is that the charge got a chance to become heated up during the suspension. It is generally considered that heat is reduced when the blast is stopped and a more feasible explanation of the increased speed of melting under the circumstances noted is that the steel was absorbing the necessary carbon to become saturated during the suspension. When the heat was turned on again, the extra heat or extra carbon required to upset the equilibrium was much less than before.

The principal rules to be observed in melting semi-steel mixtures may be summarised as follows :—

Work the cupola hot.

Select the scrap according to its section and avoid massive pieces.

Use clean scrap.

Reckon that the steel in the cupola will contain from 1.70 to 2.00 per cent. carbon when melted and base calculations on these figures.

Estimate and provide for the silicon in the casting according to this basis, keeping in view the section of the casting as in ordinary iron mixtures.

Above all take care that the metals are thoroughly mixed, and with this end in view have the metal hot from the cupola.

Experience shows that the shrinkage and contraction in semi-steel castings are greater than in cast iron, the amounts varying with the proportions used. With the lower percentages the variation is only slight but it becomes more pronounced as the proportion of steel is increased, and should be provided for by a corresponding increase in the sizes of the heads and risers.

Owing to the reduction of phosphorus, etc., the range of fluidity of semi-steel is shorter that that of cast iron and the metal sets quicker. To meet this it will be necessary to pour hot, involving attention to the refractoriness of the facing sand, and to provide ample gates and runners so that the metal may get to all parts of the mould in the shortest time possible.

Castings made from semi-steel mixtures show a close-grained structure when examined under the microscope. The graphite is seen to be in small curly flakes, while the pearlite persists in the sorbitic form. It is due to this influence on the structure that the addition of steel scrap does undoubtedly strengthen a weak and open-grained cast iron.

To demonstrate the effect of adding steel scrap to cast iron a number of test bars were prepared, firstly, from the pig-iron only, and secondly, from a mixture of the same pig-iron with steel scrap. The average of the results obtained are shown in the following table and micro-sections of typical specimens are represented in Figs. 5 to 9. An examination of the latter will reveal the changes above indicated and explain the reason for the increased strength obtained by the use of the steel scrap.

Fig.		Si.	C.C.	Tensile tons.	Transverse Lbs. 2" × 1" bars
5	West Coast Hematite ..	2.8	—	9.80	2,700
6	West Coast Hematite with 25% steel scrap ..	2.2	0.56	12.50	3,360
7	General Jobbing Mixture .	1.87	0.50	11.75	3,425
8	General Jobbing Mixture with 25% steel scrap ..	1.5	0.70	14.70	4,400
9	Hard Mixture with 15% steel scrap	1.36	0.72	17.15	3,360

The writer has to acknowledge his indebtedness to Mr. I. Logan, Ardeer Foundry, Stevenston, for providing the test bars.

Induction Furnaces in the United States.

The first Röchling-Rodenhauser induction furnace to be put in operation in the United States is at the works of the Crucible Steel Castings Company, Pennsylvania. At present it is intended to charge only cold metal, melt it and refine it. Room has been left for a preliminary melting furnace, to be installed when the capacity of the electric with cold charging on single turn has been reached. The furnace has a capacity of 1,200 tons annually with cold charging, and 2,850 tons with hot charging, both on single turn. Good steel can be made by old open-hearth melters without difficulty, the reason being that the melter can keep his whole mind on making steel without being distracted by an irregular heat supply, spot heating, frozen corners, or broken electrodes. With this furnace, assuming that the moulds are always in good condition, it is claimed that there are several features which facilitate the making of good castings. First, the steel is thoroughly deoxidised and pours as well, if not better, than the best crucible steel. Second, while the steel has any desired temperature it is not "blowy," as converter steel is apt to be, nor do the castings suffer from "heat" or sulphur cracks. Third, a thorough reducing action is easily obtained toward the end of the heat without reducing the temperature. The quality of the electric steel made is equal to or better than that of crucible steel, the cost of production per ton being approximately as follows :—

	£ s. d.	£ s. d.
Raw material (scrap)	3 0 5	
Oxidation loss about 2%	0 1 2	
		3 1 7
Current, 844 kw.-hours	1 5 0	
Fluxes	0 3 2	
Ore	0 0 3	
Labour	0 6 3	
Tools, repairs and bottom	0 3 2	
Cooling air for transformers	0 0 6	
Total Conversion Cost		1 18 4
Interest 5%, depreciation 10% per ton, about		0 6 3
Cost of one ton of electric steel ready to pour		£5 6 2

According to various calculations and tests, the amount of theoretical electrical energy necessary for melting to a tapping temperature a ton of 2/3 scrap and 1/3 pig-iron is given at 489 kw.-hours. This figure has also been given as 430 kw.-hours for mild steel when tapping at 1,650 deg. C.

Alloying of Aluminium.

By C. H. Ivinson.*

It is generally admitted that pure commercial aluminium is entirely unsuited for most engineering purposes, owing to the fact that it is too soft, has little mechanical strength, is rather difficult to cast, and does not lend itself to easy working. In general engineering work the alloys of aluminium are much more important than the pure metal; but the indescriminate use of metals to form aluminium alloys has given the latter metal a bad reputation. Aluminium alloys with every known metallic element, accompanied by disengagement of heat, and is particularly active in combining with copper. Most of the alloys are chemical combinations of the metal, rather than mechanical mixtures, the alloys with lead, antimony and mercury being exceptions, as these metals do not alloy very easily with aluminium.

The useful alloys of aluminium seem to fall in three groups, viz.:—

(1) Aluminium containing not more than 10 to 25 per cent. of added metals.

(2) Metals containing not more than 10 to 15 per cent. of aluminium.

(3) Alloys of rare metals with aluminium containing from 0.5 to 5 per cent. of added metal.

In order to make aluminium harder, stronger and of better wearing properties, at the same time keeping its valuable lightness and beautiful colour, it is alloyed with small percentages of such suitable metals as manganese, zinc, tin, copper-nickel, etc. It has been the writer's privilege to alloy aluminium with almost every metallic element, some of the resultant alloys being only curiosities, the cost of production making them of no commercial value.

For the purpose of the present Paper the writer will first briefly deal with the commoner alloys, the best known being an alloy of copper and aluminium containing from 4 to 10 per cent. of copper, and the aluminium-zinc alloys containing from 8 to 30 per cent. zinc. Zinc is the cheapest known hardener of aluminium, and in quantities of up to 15 per cent. combines to increase the rigidity and strength of the aluminium. Tin when alloyed alone with aluminium appears to develope brittleness, and alloys of 15 per cent. of tin and aluminium have been known to entirely disintegrate in the course of a few days. Nickel added by itself to aluminium produces unstable alloys. An alloy of 4 per cent. nickel has been shown to disintegrate in a very short space of time after being cast, but the introduction of a third element such as copper is an advantage. Phosphide of copper added in quantities of 1½ per cent. to a zinc-aluminium alloy containing from 12½ to 15 per cent. zinc gives fluidity to the molten metal. Phosphide of zinc containing 25 per cent. phosphorus may be substituted in the proportion of 0.05 per cent. This is one of the best fluxing and cleansing agents the writer knows for all aluminium alloys, and should be added to the molten alloy for a few minutes before pouring by wrapping in paper and plunging to the bottom of the crucible by means of tongs and stirring briskly.

Magnesium-aluminium alloys containing 1 to 10 per cent. magnesium are much improved by the addition of 5 per cent. zinc, as this addition imparts better wearing properties to the metal and aids in producing homogeneous castings. By the addition of 1 per cent. phosphide of copper less oxidation of the metal takes place during the melting operations.

A few notes on the behaviour of the alloys of copper, nickel, magnesium and zinc may be appreciated. All these alloys have good tensile strength when newly made, but in the course of time chemical and electrolytic actions render some of them very brittle, and in a good many cases lead to the entire disintegration of the alloy, especially if iron, sodium and silicon are in the metals as impurities. Aluminium is very liable to take up silicon from the crucible, especially if overheated. It is most important that these alloys should be melted without fluxes—fluxes such as mixtures of sodium and potassium chloride. Zinc chloride acts on the crucible, thereby causing the aluminium to wet the sides of the crucible and dissolve out the silica which in the presence of moisture liberates silicon hydride, which, in time, causes the entire disintegration of the alloy. Too much stress cannot be put upon the fact that the metal must be melted at as low a temperature as possible, namely, a temperature which will cause the metal to become fluid. Aluminium absorbs sulphur at a brigat red heat, and the gas is liberated when the metal is poured into the moulds, causing porous and "blow-holey" castings. Aluminium alloys should always be melted in crucibles having good tight-fitting lids to prevent, to some extent, the absorption of sulphur from the fuel being used. Aluminium when heated to too high a temperature also absorbs nitrogen and hydro-carbons. The writer has found a small piece of potassium nitrate (an egg-spoonful to 100-lbs. of metal) wrapped in filter paper, to be the best means of removing these occluded gases. A brisk reaction takes place which expels these occluded gases. After the reaction has ceased the metal is poured at as low a temperature as possible, the pouring temperature affecting the tensile strength in a very marked degree.

After numerous tests the writer is of the opinion that silicon and sulphur are two of the deadly enemies of aluminium alloys, especially when the metal is overheated. One of the best types of furnaces the writer has found, after a great many trials, for melting aluminium and its alloys is a furnace which uses gas and air under pressure, which is blown in by means of a Leimans' blower. Such a furnace is made by Messrs. Fletcher, Russell & Company, Limited, of Warrington, and is ideal for melting metal, especially if fitted with a tilting device. The pressure used on the blower is 4 to 6 lbs. per sq. in.

It is always advisable when making up an alloy of aluminium to make a concentrate of the metal which is to be alloyed with the aluminium, *i.e.*, to first make, say, a 20 or 25-per cent. concentrate metal and add this in the proper proportions to the molten aluminium.

During the last few years metallurgists have been experimenting with some of the rarer metals, and this part of the subejct is most interesting. The writer has personally alloyed aluminium, as previously stated, with almost all the rarer metallic elements, such as cerium, neodymium, lanthanum, tantalum, zirconium and beryllium, and some of these alloys gave most remarkable results even in quantities of only 1 per cent. and under. Cerium

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and beryllium are particularly interesting, 0.5 per cent. of cerium exerting a most wonderful effect on the aluminium, raising the tensile strength of the metal from 4.5 tons per sq. in. to 10.3 tons per sq. in., and giving an elongation of 8.5 per cent. on 2 in. The *modus operandi* is to reduce the fluoride of cerium. This alloy was placed in sea-water and boiled for 60 hours; the sample was carefully weighed before and after the boiling process, and it was found that the metal was the same weight as before being experimented upon. One side of the metal was polished and after the boiling it was found to be untarnished.

Another interesting alloy is one of beryllium or glucinum. An alloy of 2 per cent. beryllium gave a tensile strength of 11.8 tons per sq. in. with an elongation of 10 per cent. on 2 in. It was of a beautiful silver-white colour, and could be hammered out cold into leaf; it also withstood the action of sea-water perfectly. This alloy was made by the reduction of beryllium fluoride.

A good many experiments have been made during the past two or three years with alloys of manganese, titanium, chromium, molybdenum, tungsten, etc., and a few notes may be here given on the behaviour of these metals when alloyed with aluminium. They form a very interesting series of alloys, either when alloyed by themselves or in the presence of copper. Titanium and chromium alloys are both affected by sea-water and ordinary atmospheric conditions. The former alloy, when polished in the presence of sea-water, developes white spots on the metal which, when removed, show deep pit marks on the surface of the metal; and the same remarks apply to the alloys of chromium. Two methods have been employed to manufacture these two alloys:—(1) The reduction of titanium and chromium oxide in a magnesite-lined crucible by means of powdered aluminium: (2) the reduction of the oxide of the metals by molten aluminium, using cryolite and potassium chloride as fluxes. The *modus operandi* is first to melt the cryolite in the crucible and dissolve the oxide of the metal in the molten cryolite and adding to the same molten aluminium, when a complete reduction of the titanium and chromium takes place. Calculating the amount of metallic titanium required, $3\ Ti\ O_2 + 4\ Al.\ \ 3\ Ti + 2Al_2O_3$. These metals give very rigid and hard alloys. The tensile strength of the one containing 2 per cent. of metallic titanium was 10.4 tons per sq. in., and the elongation 4.5 per cent. on 2 in. The alloy with chromium, containing 1.5 per cent. metallic chromium, had a tensile strength of 9.34 tons per sq. in., with elongation of 2½ per cent. on 2 in. But the behaviour of these alloys in resisting atmospheric conditions was far from satisfactory.

Tungsten has been recommended as being a suitable metal to alloy with aluminium to resist corrosion, but in the hands of the writer this has not proved very satisfactory. An alloy containing 2 per cent. copper and 0.5 per cent. tungsten rapidly disintegrated under ordinary atmospheric conditions. At least 100 different samples of this alloy were prepared in the varying proportions of 0.2 to 5 per cent pure tungsten alloyed by itself with the aluminium, and also in conjunction with nickel, manganese, copper, etc. The results of some of these were disappointing. The alloy of zinc and nickel containing 3 per cent. nickel and 0.75 per cent. zirconium gave extraordinary results as far as tensile strength was concerned, having 12.2 tons per sq. in., with elongation 9 per cent. on 2 in. Its behaviour in sea-water was very extraordinary; it was boiled for 72 hours in sea-water, and when tested, after the boiling process, it only showed 4 tons per sq. in. tensile strength; its fracture was very crystalline, and it was also very brittle.

Zirconium 0.75 per cent., when alloyed with aluminium without the presence of nickel, gave the same tensile strength after the boiling process as before, namely, 9.3 tons per sq. in. Molybdenum when alloyed with aluminium had the opposite result. An alloy was made containing 1.5 per cent. molybdenum with aluminium which, after being boiled in salt water, gave a lower tensile strength than before the boiling; but when the molybdenum was alloyed with the aluminium in the presence of copper in the proportions of molybdenum 1.5 per cent., and copper 1.5 per cent., the tensile strength of the metal after the boiling process was the same as originally. This makes the theoretical alloying of aluminium a very facinating subject, as it is almost impossible to theorise or to account for the peculiar behaviour of these different elements when combined alone or in conjunction with another in aluminium. Within recent years several alloys have been put on the market for which sea water resisting properties and resistance to ordinary atmospheric influences are claimed. It is no doubt working on the above lines that such alloys have been made possible. The only drawback of the rare elements is their prohibitive costs, but it is to be hoped that chemists and metallurgists will go on experimenting to produce these rare elements at a commercial price; and no doubt a lot has been done in this direction since the advent of the Goldschmidt process for the reduction of the rarer metals from their oxides by means of powdered aluminium.

There is no doubt that aluminium has obtained its bad reputation through the unscientific mixing of metals, and the compositions of some of the most successful alloys which withstand the action of sea-water are rigidly guarded as secrets. Aluminium was boomed too greatly some years back; it was put forward as being the cure-all for blowholes in brass, iron and steel, also for promoting the fluidity of zinc for galvanising processes, etc. In the writer's opinion aluminium ought to be added very sparingly to brass, especially if the latter has to be remelted several times, as on each re-melting the aluminium oxidises, rendering the brass porous and reducing greatly its mechanical strength. The same applies to steel; the aluminium ought to be added extremely sparingly. For steel it is better added as a titanium-aluminium alloy and for the brass as a manganese-aluminium or titanium-aluminium alloy; for titanium and manganese seem to counteract the evil effects of the aluminum. The writer has used an alloy of 50 per cent. titanium and 50 per cent. aluminium with very good results, whereas, when the aluminium was used alone, very defective castings resulted.

The subject of the practical alloying of aluminium covers such a large field that it is impossible to give fuller details in so short a paper as this.

THE sale by auction of the plant and machinery at the Thames Ironworks, Greenwich, was unexpectedly stopped on May 28, in consequence of an order of the High Court, under which the plant and machinery still remaining to be dealt with had been sold to Mr. W. Defries, of the firm of Defries, Limited, ironfounders and engineers, of Antelope Foundry, Deptford, who had purchased a considerable number of the lots offered on the previous day. It is understood that on the conclusion of the necessary arrangements Messrs. Defries will reopen the works with a view to the extension of their business.

The Economics of Industry and Education.*

By Alexander Hayes.

In the course of recent discussions on industrial training, the complaint has frequently been made that the various schemes of educational reform put forward do not take into full consideration the economic side of the subject. The object of the present Paper is to show the fundamental economic relations between industry in its various developments and education generally. An attempt will be made to show how education is an essential in industrial progress and to outline briefly the development of industry which has made necessary an advance in educational methods. Under the complex conditions existing to-day the fundamental principles governing industry and national life are almost entirely obscured by superficial factors, and when those factors are considered apart from the fundamental principles, it is extremely difficult to arrive at a solution to the problems that arise. Social and economic conditions, too, are changing so rapidly that a conclusion based upon the observations of yesterday, without regard to the fundamental principles, may be negatived to-morrow, owing to the introduction of some new and unlooked-for consideration. Once, however, establish the principles upon which the evolution of industry is based, and it is not difficult at any time to go to the root of any problem which arises and discover in what way the requirements of progress have been contravened or may be met.

So much so have the difficulties caused by ignoring fundamental principles entered into the treatment of economics, that the writer considers it would be advisable for the average student to disregard entirely all works on economics published more than ten years ago. There are, admittedly, various earlier classical works of considerable value, but at the same time the correct comprehension of the arguments put forward necessitates a clear appreciation of the social and other conditions obtaining when the books in question were written. A student in touch only with modern conditions is seldom able to attach the full value or meaning to any doctrine unless the principles, as applicable to any variety of conditions, are properly enunciated.

With the foregoing in mind the writer proposes to briefly survey the evolution of industry in its various aspects, the apprenticeship system as an ancillary process, and the general development of the education and training of industrial operatives to meet the requirements of industry's evolution. This survey naturally involves a number of side issues and leads ultimately to the connection between our present educational system and its service to industry and civic well-being. In passing, the writer would emphasise the fact that he is not arguing purely in favour of the maximum efficiency in the production of so-called commercial commodities, but for that efficiency which includes the physical, intellectual and moral well-being of every unit of the community. For this is the only true aim of industry, though it is often obscured by the supposed requirements of the moment, which demand merely efficiency in some specific operations.

It will also be shown that industry itself is not an end, but merely a process to attain an object and maintain a status. Under the heading of "The Necessity for an Ideal," the writer discusses the object to be attained, and if the ideal set forth be accepted, it will at once be apparent that industry is not the objective, but the means. Industry is a process which has developed as the result of a number of factors operating in various and opposite directions. These factors will be discussed in greater detail under the heading of "The Evolution of Industry," but may briefly be stated as follows:—

(1) Improvement in the standard of living or increase in the total requirements of the individual.

(2) Decrease in the products obtained from natural resources for the same unit or amount of energy applied to those resources, by reason of depletion and exhaustion of those readily accessible, and decline in fertility through use of such resources as land, etc.

(3) Increase of the population utilising unincreasing resources, and hence the necessity for their more perfect utilisation and the discovery of further resources.

(4) Consequent on the foregoing, increase in the effort applied to resources, or improvement in methods or processes and apparatus so applied as to increase the production for the same amount of effort.

These four factors are at the base of the whole of our economic problems. They are responsible for what we know as industry and, further, they explain at once the necessity for increased efficiency in the effort applied to the country's resources. It will be shown later that the chief purpose of education is the attainment of ever-increasing capacity to meet the increasing requirements of the factors above-enumerated. Accordingly there can be no reason for the strong line of demarcation frequently drawn between industry and education.

Chapter I.—The Necessity for Clear Ideas and an Ideal.

Clear ideas on familiar things are very difficult to obtain, but they are essential to an intelligent discussion of the relations existing between those things. For the present purpose it is necessary to decide what is the nature and purpose of industry, and also what is education. Education is, strictly, the development and training of a faculty or faculties for a purpose, that the trained person may be able to do something better than formerly; and a person who is acquainted with even the most exhaustive collection of facts may still be in no sense educated.

A study of the rise of industry from its earliest stages will reveal that its essential object is to make possible the *maintenance, development and reproduction of the species, first from the physical and later from the intellectual and moral standpoints.* This purpose of industry, for the sake of brevity, will be referred to in this Paper as the ideal or objective. Any contention, any system, or any scheme of operation which proves itself to conflict with this essential object is the result of the latter being obscured, and seeming advantages not being investigated. Moreover, although any particular scheme or line of operation may involve details which conflict with the ideal, on careful consideration very often the advantages may be retained and the objectionable features eliminated.

As a simple illustration may be taken the case of any works. The aim of the works manager is generally to produce at such a rate and under such con-

* British Foundrymen's Association Convention Paper.

ditions the desired material so as to return the highest possible profit continuously on the capital invested in the concern. This object may be attained by one of several methods, involving perhaps the underpayment of a portion of the workers, the saving of money which should be spent on providing working conditions of reasonable comfort, and, for a period, less than the necessary outlay on new plant and maintenance. In other ways, too, this works may operate to the detriment of the community in which it exists, and in conflict with the ideal of industry, while at the same time attaining what may appear to be desirable results from one standpoint. It is obvious, however, that though even for a protracted period these works may be conducted with good results from that standpoint, they are not being conducted to ultimate good. For centuries now this fact has been recognised in the various legislation that has been passed governing industry in its different branches. If the case cited were examined in the light of the ideal, it would be condemned as not conducing to the ultimate prosperity of the community, or of even the industry concerned.

In a minor degree the conditions mentioned obtain in nearly all individual plants, except where the larger outlook is taken and detriment to the community is appreciated as affecting the individual concern. Particularly with small concerns, the working to a false and personal standard does not readily display its fallacy, and hence temporary success when viewed from only the one standpoint often appears to confirm the false standard as being sound. Ultimately the operation on lines contrary to the industrial ideal must react to the detriment of the industry and often the individual concerned, but the process is sufficiently slow to be obscured until the subject is carefully considered in regard to its fundamental principles. It will appeal as quite logical to the average man to state as an axiom that any process which tends to deteriorate the capacity of any branch of workers must ultimately be to the detriment of the industry concerned, but at the same time this fact is studiously ignored by many in answer to the apparent requirements of the moment.

The point which the author desires particularly to insist upon here is the necessity of keeping in view the true object of industry so that every question raised can be directly applied to it and the defects in any system discovered.

Chapter II.—The Evolution of Industry from its Elementary Phases.

With the development of human consciousness there has arisen a demand for a wider utilisation of nature's products, involving a higher standard of living and a consequent greater exertion on the part of the individual to maintain that standard and improve it. It can serve little purpose to trace the development of industrial activity from its earliest stages, when savage man commenced to supply his requirements by organised effort. In fact, the process cannot well be traced, as it is now too remote; but it probably resulted from the exhaustion of the requirements of life which could be obtained with no organised effort, necessitating the development of the mental and physical capabilities in order to maintain life. This process naturally would widen the conception of what among nature's resources could be enjoyed.

The reproduction of the race, under the improved conditions created by bringing human intellect to bear upon natural resources, has become more rapid than under the restriction of nature's law as applied to savage life, where the unfit are eliminated and any overcrowding is met by the survival of only the toughest. This increase in population and rise in the requirements of humanity has been naturally accompanied by a decrease in the amount of produce resulting from the same amount of effort, by reason of the depletion of natural resources and the exhaustion of readily-available supplies.

With the two factors of supply and demand following divergent courses, the development of humanity can obviously only continue when some third factor is introduced to bridge the gap. It will also be readily comprehended that though for a time increase of physical energy on the part of humanity may meet the requirements of the case by increasing the production from the available sources of supply, there is a limit to this increase of effort, and it is here where invention and organisation are called into play. Invention implies the devising of appliances, apparatus and processes for obtaining a greater production by the same amount of physical energy and for harnessing available supplies of power in place of human energy, and also the application of science to further aid production. As the discrepancy between resources and demand becomes greater, the greater must be the development of the compensating factors if the standard of living is to be maintained and discomfort and distress subdued; and still greater must it be if the standard of living is to advance.

The operation of the forces mentioned would suggest at first sight that there is a marked movement towards the exhaustion of nature's supplies, but it must be remembered that so far from the effort required to improve and maintain the standard of living becoming greater, the application of invention and science has (1) rendered production from available resources easier, (2) discovered new resources and substituted others for those being exhausted; and (3) converted into usable resources a large variety of materials which formerly, in the absence of present-day knowledge, were useless. Moreover, the introduction of transport facilities has allowed the better distribution of produce and a consequent saving through regular production and the avoidance of waste; and has also opened up huge resources in those countries which are practically unpopulated. In this way, for example, the wheat requirements of England, instead of demanding laborious and difficult production in England and a consequent neglect of other industrial operations, are met by the ready supplies of several continents which have all the facilities for a huge production, while exhibiting only a small home demand.

As regards the depletion of natural resources and the reduction in fertility through use, mentioned previously, this has to a great extent been overcome by, for example, methods of manuring and cultivating in the case of agricultural pursuits, increased facilities in the way of machinery for obtaining minerals from greater depths, and the application of science for separating useful materials from the (at the moment) unusable products with which they are found associated. The blast furnace of to-day in this way produces first-class iron from materials which primeval man found useless, and also from materials which a century ago were not usable.

In the face of this it would be rash to form any assumption regarding the exhaustion of nature's supplies, since each generation finds an application for something of which previous generations were scarcely cognisant; and even in the direction of producing food, the developments of science have indicated and made available supplies which only a short time ago were unknown. It is, of course, possible that this development cannot proceed indefinitely, but we are sufficiently far from the climax to prohibit even hazarding a suggestion regarding exhaustion. It appears at the moment quite feasible, to take a concrete case, that before the world's supply of coal is

exhausted the utilisation of the sun's rays will have become a recognised means of obtaining power, and hence lighting. Touching the application of science, it may here be remarked that artificial light has been the means of greatly aiding production, rendering operations possible in situations and under conditions where they were impossible; lengthening also the possible time of operation per day and, where necessary, enabling continuous operations to be carried on efficiently.

This process of combating the exhaustion of nature's supplies has, as stated, resulted in the development of the human conception of what may be enjoyed, until in the process of time a complex variety of demands by humanity has been created, some of which arise from the processes of producing the absolute necessities for maintaining life and others from a desire to participate in physical and intellectual enjoyments unknown to primeval man.

The developments here outlined have involved increasing organisation, and this organisation we know as industry. It is the direct acknowledgment of the forces which are in operation, and it is at the same time the answer to the problem they create. Nature sits ever with a Sphinx-like relentlessness propounding to mankind her increasingly difficult problems, and, as of old, failure to answer those problems adequately involves extinction; and as the years go by the intellectual development required to answer becomes greater and greater.

To follow even in outline the progress of industrial evolution through the centuries would occupy too much space at the moment, and is scarcely necessary for the purpose in hand. It is fairly well understood that the organisation of production mentioned previously has involved the division of labour between the various operations, in order to secure economy; for organisation is essentially the allotment of different duties to the most efficient for those duties. This division of duties has continued to such an extent that no individual in any civilised and industrial community is the consumer of more than a tithe of the actual product of his labour, and in very many cases is consuming none at all of this product, but simply exchanging it for a share in the varied products of a host of other labour. While this fact is generally acknowledged, it is not so generally appreciated, and, moreover, it obscures the basic fact that the purpose of each individual's work is to create or produce all that is necessary to satisfy that individual's requirements. Nevertheless, all useful work is directly associated with the discovery, preparation for use, distribution and consumption of Nature's resources, whether these be applied to the maintenance of life itself (as is the case with food), the enjoyment of physical comfort, the indulgence in pleasures and recreation (physical and intellectual), or the preparation and training of the young for participation in industrial and civic activity.

It will thus readily be seen that useful work covers a field far wider than the production and preparation of actual materials; it includes the handling, distribution and processes of exchange of those materials, the attention and mental effort required in organising that distribution and exchange, the devising of appliances to aid all branches of industrial activity, the attention and effort required to train the young and inefficient, and also all the labour required to create and place available the means and facilities for enjoyment and recreation which is demanded by the whole community.

It may be mentioned, as a side issue, that in discussing industry and its problems, there is no purpose served in drawing any marked distinction between the "producer" so called (*i.e.*, the worker whose labour gives a tangible and material product) and the numerous labourers whose work contributes to the other requirements of the community. This is a simple but vital point which, curiously, is frequently ignored by many who discuss the problems of industry. If the ideal or objective of industry were merely the maintenance of life itself, the case would be different, but it has been shown, and will hardly be contested by intelligent persons, that the ideal is very much wider than that.

Reverting to the evolution of industry, it must be pointed out that industrial organisation for a long while partook chiefly of the nature of local co-operation between workers to avoid waste of effort and secure greater efficiency in their aggregate effort. Industrial activity thus was largely conducted in self-contained circles, each comprising an industrial community with little or no real association with any other. This is probably nowhere better illustrated than in the old Greek cities, where each "Polis" was practically a self-supporting and self-contained nation.

At this period in the development of industry, and, in fact, up to within the last century or so, physical labour was aided by only simple and elementary appliances, which depended on hand or similar power for operation, and, with the exception of the wind-mill, the water-mill and the application of animal labour, human power (aided and rendered more efficient by appliances and mechanism) was the only power available. The birth and development of the power plant, however, set afoot a new industrial movement, amounting in actual fact to a steady *revolution*. It is, without doubt, to the power plant we owe our present state of industrial development. Formerly the congregating in centres for the more convenient and economical conduct of industry had certainly been a feature of industrial evolution, and the factory system had to some extent come into vogue, as witness the cotton and wool-weaving industries. But the rapid development of the factory and concentrated activity which followed the rise of the power plant was out of all proportion to earlier movements in this direction. Whereas formerly a nation consisted chiefly of a collection of industrial communities each for the most part self-contained, the industrial activity accompanying the rise of the power plant distributed production far more widely and made the nation itself one large community.

It was only natural that the application of power which rendered operations so much easier and more rapid should cause a marked change in the conditions of industrial activity. The result was that from being a minor development, the factory system in its various phases became in time dominant, until to-day the domestic or individualistic method of production exists in most industries as a dying relic of a former age.

The foregoing development of industry, it will be seen, has been a normal process, resulting from a number of factors; and it has in the main tended to serve the attainment of the objective or ideal stated in the opening chapters of this Paper. It has more than maintained life; it has enabled each individual to enjoy more than the variety of nature's products which he alone is capable of producing, by reason of exchange of some of those products which he can readily produce for the corresponding products of others. The standard of living has risen, and the variety of products available for the race has increased with the specialisation and organisation of productivity. It is only reasonable to suppose, too, that this specialisation and organisation will continue until a practicable maximum is reached. What that practicable maximum will be must be determined by

the ideal or objective; and here again the importance of establishing an ideal is evident, for were industry itself the objective, this specialisation and organisation might continue to the extinction of individual initiative and responsibility in the great majority of the race. But that is not so; and already there are many expressions of discontent at the restrictions of our increasingly comprehensive organisation.

It accordingly becomes necessary to enquire whether the practicable maximum has been reached, or whether there are unessential factors now associated with organisation which are objectionable and which may be eliminated. This phase of the subject is discussed later, under another heading; at the moment there are some other aspects of industry which may be reviewed before passing to the solution of the problems presented.

Chapter III.—Resources and Production.

In discussing the question on hand, it is essential to establish a clear idea as to what comprise the resources of any nation engaging in industrial activity. In the sectional discussion of the subject as applied to, say, one particular trade, the resources of that trade generally imply the raw materials and facilities for working them which are available or potentially so. At the moment, however, the term resources must be given a very much wider interpretation and be made to include all the raw materials, facilities for obtaining and converting them, all service and facilities exchangeable in commerce, and, finally, the aggregate capacity of the nation to produce and utilise all the products necessary for the maintenance of its physical, intellectual and moral well-being. Accordingly, the degree of efficiency of the workers in all departments of industry constitutes an essential part of the resources of the nation, since an inferior degree of efficiency implies less capacity to meet its requirements. It might also be said that the resources of a nation include the potential capabilities of its workers. If this be acknowledged, it naturally follows that not only is it essential to utilise to the best the materials supplied by nature, but to also maintain and develop the individual capabilities of the nation to turn to account every possible material as its application becomes necessary or desirable.

It may be taken as a broad general principle that each individual or section of an industrial community should produce that which it is most capable of producing so far as that commodity is exchangeable in the world's markets for other necessary or desirable commodities, in excess of the quantity of the latter which could be produced in the same time as the article exchanged. This, of course, involves the supposition that where such exchange takes place it is not subject to the possibility of such interruption as would be disastrous to the consumer. Where such an interruption of supplies in exchange for the most easily-produced commodity is a contingent factor, it becomes necessary to produce even at a higher cost than in another community all those commodities which are necessary in order to ensure a supply under all conditions. In considering the cost of producing, moreover, the cost involved in effecting the exchange for some other commodity has to be taken into consideration, and accordingly we find most communities each producing a variety of articles of the same nature and at different costs, since the difficulty of exchanging, owing to the location of manufacture or lack of near outside demand, would render the production of only the readily-produced commodities valueless. At the same time, local facilities and natural resources generally enable one or more products to be made in any particular community with greater advantage than others, and thus we find various industries tending to centre themselves at different spots. In some cases it is even found that the industry in question absorbs practically all the productive labour of the district, since the outside demand at the price of which the goods can be marketed is sufficient to allow of all other products required by that centre being obtained in exchange for the sole commodity produced.

It must not be supposed, however, that the principles mentioned are regularly observed by all industrial nations. It has been a feature of industrial evolution that each community, and on a larger scale each nation, has endeavoured primarily to supply all its own requirements, and only during the last few centuries has international exchange of production figured largely in any nation's economics. This means that many industries still survive which are producing at a disadvantage, which disadvantage only becomes apparent when competition from outside sources reveals the possibility of cheaper production in other districts. The expansion of industrial exchange, therefore, is constantly revealing what, at first sight, appear to be industries ruined and destroyed by outside competition.

It must, of course, be admitted that any district, while producing its most readily-produced commodity, may still suffer from the competition of other centres better situated in regard to facilities or resources. In such case the badly-situated district can obviously not secure the same balance of profit in market exchange as can the better-situated district, though in many cases the discrepancy can be adjusted by the adoption of labour-saving methods and new processes and appliances. It is at this point in particular where the intelligence of the community is effective in overcoming its natural disadvantages, and it is a noteworthy factor that some of the shrewdest and best intellectually-developed nations are those whose natural resources are relatively small compared with others. It would seem that the conflict with these disadvantages and the struggle to wrest from nature the requirements of life have stimulated the intellectual activity of the people.

In view of these facts, while the principle outlined in the opening sentence in this chapter is sound, there are modifying factors which may extend its application to certain products which, at first sight, may seem to be outside the range of readily-produced commodities. In other words, the most valuable resources of any community can only be correctly ascertained when there are taken into consideration the following factors:—The various facilities or resources available; the cost in some other district of producing the same products; the cost of exchanging any product; and the possibility of reducing the cost of production by improved methods and appliances.

The relation of these various factors in any industrial community is continually having to be reconsidered, and thus it is found that industries shift from centre to centre as the conditions of the moment alter, and districts, for example, which were once largely productive, have become rather distributing centres, owing to the above-mentioned reconsideration of their facilities. At first sight, the industries of any country often appear to be the subject of numerous eccentricities and vagaries of fortune; but when examined closely it will almost invariably be found that the factors above outlined are operating on very definite lines, and the influence causing changes can frequently so be traced.

The same principle applies to labour in the individual as to directions of production for the community. As a general rule it may be taken that each

individual should operate in that direction in which he is most capable, but this rule requires modifying according to the demands existing for the labour in question. Hence, where in any community a large number are most capable of performing a certain operation of which little is required, some of that labour must be redirected into another and the nearest efficient direction, if that labour in turn is required. No rigid rule can be applied, for the circumstances of the moment must dictate. Only the general rule may be stated and applied to the individual, namely, that each should operate in his own most efficient direction, subject to the conditions named. Here, again, the function of education in producing a flexibility of wage-earning capacity is important, since it allows redirection of such effort as is not required in the most efficient direction, this re-direction being only possible through the medium of training, which is education.

Chapter IV.—The Utilisation of Labour and its Preparation for Use.

It has been shown in the chapter relating to the evolution of industry that the conditions of to-day necessitate for the provision of man's sustenance, not comparatively slow activity for the whole of his life, as was the case when rural activity represented the chief productive process, but a period of highly-intelligent specially-directed and organised activity, necessitating particular and varied qualifications in each worker. Since, also, this activity cannot be possible without some preliminary preparation, on account of the nature of the processes and apparatus employed, it is not economical to introduce the operative to the work until he has obtained a certain degree of mental and physical capability. Participation in actual production at the same age as formerly is now wasteful, in that it is inefficient at the moment to provide for the sustenance of the worker in question and, moreover, prohibits the attainment of ultimate proficiency to provide for the maturer requirements of the same individual. Under past conditions, when even a competent operative's labour was characterised by extreme simplicity, it was quite possible to start a boy at work as early as he was physically capable of performing useful operations (so long as he was not overtaxed), and in the course of intimate contact with the work which he would later have to do, he developed the necessary capacity to produce efficiently for his ultimate sustenance. In fact, that course of training was the only one available under the conditions then existing, and since it met the requirements of the times, to delay participation in production to, for example, the present age of 14, was to waste a number of years of useful productive activity. Through the centuries that followed up to the present day, however, the conditions underwent a marked change, so that to-day it would be a waste of effort and appliances to start a boy operating at anything but the simplest of work until he had attained a certain development.

The question which then arises relates to the required preparation for participation in industrial activity, the time it should take, and whether it should be distinct from industrial activity itself or be gradually merged into the latter. The answer is a complex one, and must be different in the case of almost every trade; but as a preliminary it has already been acknowledged that at least the first twelve or fourteen years of life should be devoted to physical and mental development, without active contact with production.

The writer considers that, providing the labour were proportioned to the physical condition of the boy, many boys who ultimately operate most successfully at unskilled work could well start work at 12 years of age; for the last two years of school life is in such cases too often a period of idleness and lack of progress. On the other hand, it is very difficult to be sure that such is the best ultimate class of work for any boy, since his development may only be slow and become much more rapid between the ages of 13 and 18. To pronounce on the most desirable ultimate work for any boy at the early age of 12 years would be to condemn to unskilled work many boys who have latent possibilities far beyond that. For skilled work, 14 years of age itself is often too early for anything but intermittent participation in actual production, and full participation may simply retard or prevent proper development; and even with two boys adapted for the same class of work, the necessary training may be very different. Again, particularly in the mechanical trades, acquaintance (without participation) with actual work may, and even does, prove a very beneficial educative influence at quite an early age, long before 14 years.

Taking any skilled operation as an example, the object of preliminary training is to teach matters which cannot be so well learned during the work itself, and therefore that preliminary training should be extended so long as the conditions obtain which make it desirable. But there comes a point at which training of that description must be barren, except in actual touch with the work to which it relates. This, the writer contends, is a strong plea for merging the preliminary training into the final training of actual participation in production. It is almost impossible to place any line of demarcation in any trade and say that at that point theoretical or school training should cease and the training in contact with the work commence. The process of development is essentially a gradual one, and it is illogical to assume that the process of training should be so distinct.

Taking for granted, then, that it is desirable and even necessary to hand down from individual to individual and generation to generation that knowledge of processes and appliances acquired by past experience, and to instruct the young worker in productivity prior to actual participation—this in order to eliminate the waste of time involved in each individual learning the full process of production by experience alone—we may now enquire as to the best means of transmitting that accumulation of knowledge, which amounts in actual fact to an accumulation of productive capacity.

It is unnecessary to go back to the early forms of training which have accompanied industrial evolution; the conditions then obtaining bear so little resemblance to modern conditions, and the systems were so essentially adapted to only the conditions of the time, that little useful information is afforded by them in the light of modern requirements. A better purpose is served by an examination of the first organised system of instruction for industrial efficiency, *i.e.*, the apprenticeship system.

Chapter V.—The Apprenticeship System.

In the very badly organised social conditions in which the apprenticeship system arose, that system was the natural outcome of an acknowledgment that systematic training or distribution of knowledge amongst industrial operatives was essential, if the capacity of past generations was to be utilised. It is readily understandable that the system was developed to meet, as effectively as possible, the conditions of the moment and that it has undergone some modification and revision by reason of social and other changes. The main principle which it embodies,

however, being a basic one, still holds good. Since the apprenticeship system has proved its value in the past as an aid to industrial efficiency, it is frequently accepted *in toto* as desirable under the conditions of to-day. In so far as it embodies fundamental principles, the author cordially agrees, but contends that the system requires modifying in strict accordance with modern conditions and recent social and economic changes. The directions in which the system should be modified will be outlined in a later chapter. At the moment it will be instructive to review the rise and decline of the old system.

As far back as the 12th century we have evidence of comparatively high organisation of apprenticeship. The principle was essentially that of taking the boy at an early age from the control of the parents and placing him under the care and instruction of the craftsman or employer who was to teach him his calling. It was then understood and acknowledged that the training should include not only instruction in the craft, but guidance in physical and moral development. The apprentice usually entered into the family life of his employer, and became identical in social status with his employer's sons. He, moreover, had a claim at Law on the instruction in the different work his employer was conducting. The result of this system was that at the conclusion of his apprenticeship the boy had a thorough insight into the whole of the working of his master's business or craft, and was in a position, under the conditions of the day, to commence business as a master craftsman directly opportunity offered. Under the then existing system of domestic production, as distinguished from the modern factory system, which necessitates large capital, the apprentice normally developed into the master craftsman. There was not the same social stratification which differentiated employer and apprentice as at the present time, for each belonged to the same social grade of craftsmen, and marriage of the apprentice into the master's family was quite a common and normal occurrence. It is important, when suggestions for reviving the apprenticeship system are mooted, to keep clearly in mind the facts that the apprentice was a potential master-man, and also received training in every department of life from his master, not merely vocational instruction. This will be borne out by an examination of almost any old form of indenture.

The system of indentured apprenticeship, coupled with the organisation of the crafts known as trade guilds, also served another purpose, namely, that of maintaining the quality of workmanship in the different crafts and excluding inefficient and bad workmanship in competition. This formed a very important duty of the organisation; in fact, it became an essential function of the trade guilds of the day to maintain this status and efficiency. Powers were granted to the guilds to prohibit operation at the different crafts by other than duly indentured apprentices or members of the guild, so that the latter acted as a sort of trade union, with even wider powers than the present trade unions. This condition of things lasted for a long while, and was responsible for much of the high development of many of our industries. But it will readily be conceived that such organisation could only apply to the skilled crafts and not to unskilled work. There was, naturally, under the conditions of the time, a fairly marked distinction between simply agricultural and rural operations and the work of the arts and crafts, the latter requiring a careful training and instruction which the former did not; consequently the restrictions and prohibitions imposed by the guilds in regard to the right to operate at skilled callings had many beneficial effects.

There arose, eventually, however, a movement which even the powers granted to the guilds could not overcome. This movement was the growth of a supply of outside labour which had not been through the apprenticeship course, but which was sufficiently capable of operating at skilled crafts to produce many of the goods in question, even though not attaining to the highest efficiency. From various causes labour drifted into the towns and industrial centres from the land, and sought employment at the arts and crafts, until there grew up a labour supply available for a great variety of work which formerly was in the hands of the guilds and their members. This movement was combated for a long time by the guilds, but it was inevitable that it could not be ultimately suppressed. The result of the movement was the gradual decline of the apprenticeship system, for while the efficiency resulting from apprenticeship could not be denied, it was difficult to insist on a long term of training before material payment was received, in the face of the other course adopted by the outside workers who gave their labour for what it was worth, without any agreement or indenture, gathered what knowledge they could and passed from point to point, enlarging their experience until they attained at an early age a fair capacity, or at least sufficient to enable them to command a good wage as journeymen artisans. This movement was greatly aided by the rise of the factory system and its tendency to segregate workers into the two classes of operatives and officers, as distinct from the old all-round craftsman operating under the domestic system.

In the face of this, it is not surprising to find that to-day, despite the high intellectual development demanded by many branches of industry, the apprenticeship system, with its organised training, has practically died out, except in those industries which can only be conducted by labour which has undergone this training. In other industries, again, a compromise is effected, and a sort of semi-apprenticeship system is in vogue in some plants, without indenture, while others, who are in a position to command the pupils by reason of their importance as industrial establishments, retain the old system of indentured apprenticeship.

But one great point of difference between the early apprenticeship system and any existing system, when the two are compared, is that while the former was responsible for the physical, mental and moral development of the apprentice, the latter is concerned only with the instruction immediately relevant to the vocation; and now many advocates of the old system, overlooking these essential points, raise objections to the suggestion that industrial training should include instruction and control of conduct in other matters, such as the civic and social life of the apprentice. It will be seen, on reference to some of the previous principles enunciated, that in many respects the earlier apprenticeship system was far more in keeping with the ideal stated by the author than are the present educational systems. The one was a comprehensive control and instruction of the boy on all sides of his conduct, and tended to make him not only an efficient craftsman, but a good citizen. The present system ignores everything beyond the vocational capacity of the boy. It will, of course, be contended that elementary school training, coupled with home training, should be sufficient to meet the case, and that, under modern conditions, apprenticeship should concern itself only with the vocation in question, since the old conditions of intimate association with the master rather than the parents is not now a feature

of the boy's life. In the main this contention is quite correct, but when the schooling and training systems instituted are found, as they have been found, to divert parental responsibility without taking its place, they obviously require revision to meet the defects. It then becomes a question as to how far elementary schooling and vocational training should be made to include the training characteristic of the old apprenticeship system. These facts will be discussed in a later portion of the paper.

(To be continued.)

Foundry Sands and Their Treatment.

By Algernon Lewin Curtis, M.E.

(*Continued from page* 298.)

A Partial Study of Moulding Materials.

The study of moulding materials would seem to embrace a number of most important subjects, viz., geology and petrology, chemistry, metallurgy, minerology, keramics, heat and pyrometry, microscopy and light, physics and foundry practice. By means of geology, petrology, and minerology can be discovered the mineral character of moulding sands, through the aid of chemistry, heat and pyrometry, and microscopy; and a good knowledge of metallurgy, foundry practice, physics and keramics enables the behaviour of metals, clays, sands, and compositions under heat and in solution to be better observed.

The best illustration of the principle of sedimentation is that of running water in streams or currents along sea-shores which transport and deposit sands. During the process a sorting action takes place according to the specific gravity and size of the different particles, the large grains of light materials becoming amalgamated with smaller grains of heavier minerals. Sand particles during such transportation become more or less rounded, due to mutual abrasion, as the larger the grain the more abundant the rounding. With equal-sized grains, however, the heavier are the most rounded. Water is not the only agent for transporting sand, as in certain countries wind has been responsible for large sand deposits, these latter being made up of finer materials than sedimentary deposits, owing to greater abrasion taking place in air than in water.

Most authorities agree that sands can be classified into three groups, thus :—

(*a*) Sands derived by assortment of glacial drift material, water, and wind currents.

(*b*) Sands derived from weathering of sandstone and other rock, usually termed residuary sands.

(*c*) Old Sandstone Formation, or rock sands, which cover large areas, being cemented by oxides of iron, silicon, etc.

Much of the moulding-sand deposits of the world are due to assortment by glacial drift, wind and water currents, and decayed felspathic rock. In order to examine the mineral content of any moulding material, composition or sand mixture, the microscope must be resorted to; but before the significance of such examinations can be made apparent, a complete set of the minerals met with in moulding materials should be studied. As the microscope appears to be something of a *rara avis* in many foundries (and here let me state that it is incumbent on every person who has charge of a foundry to possess complete reliable microscopic apparatus, not only for the examination of moulding materials, but metals also), a few suggestions on the choosing of a suitable instrument may not be out of place.

Of course, the best way to secure a good microscope is to pay the best price, but this method is prohibitive to many who do not know the points of a good instrument, and usually impossible to the beginner who desires to start as a rule without incurring too large an expenditure. Unfortunately, the market is flooded with a lot of "cheap and nasty" instruments of doubtful origin and manufacture. These are sold in polished cases containing a few useful accessories, and a fearful and wonderful assortment of things seldom wanted. This is

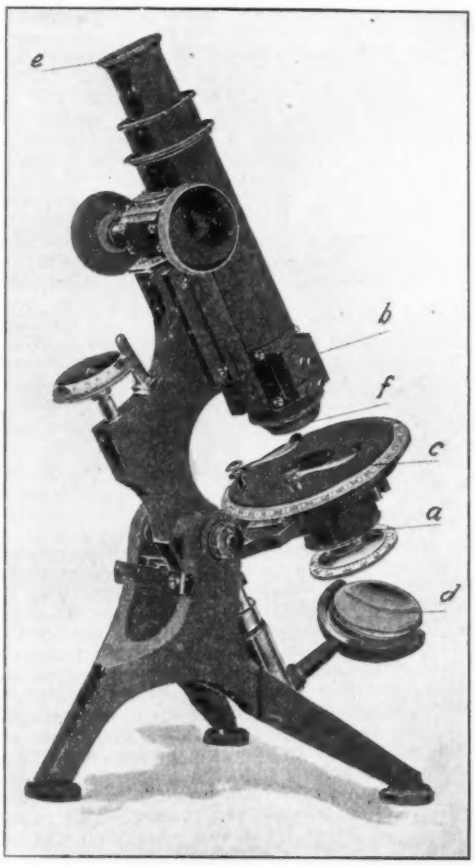

FIG. 1.—PETROLOGICAL MICROSCOPE; BY MESSRS. WM. WATSON & SONS, LIMITED.

described as a complete microscopic outfit, and is made to no design or standard.

If, however, a new microscope has to be procured it is best to get a plain one from a reliable manufacturer. The writer uses a petrological instrument by Messrs. Wm. Watson & Sons, Limited, 313, High Holborn, London, W.C. The prospective buyer would do well to state his position, and arrange suitable terms for payment, if unable to purchase a reliable instrument outright.

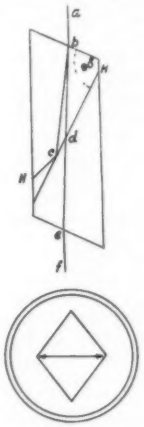

FIG. 2.

FIG. 6.

Such an instrument will be made to standard sizes and fittings, and as progress is made additional apparatus may be added as required, with the certainty of them fitting. Standard fittings by standard makers are all interchangeable, and the English makers cater best for the plain stand microscope suitable for further additions.

It is best to begin with low-power eyepieces and objectives, leaving high powers particularly alone at first, and not be misled by too much polish or show, as a microscope is to be looked through, not at. If the foundryman has any choice, he should not by any means get a microscope that cannot be inclined from the vertical, as when the eye is looking vertically down, it involves a standing position all the time, and occasionally the fluid on the eye will impair good definition if used constantly for any length of time in this position. The microscope chosen should be of recent type and should stand steady on its base, and not be easily overturned. The hinge joint for inclining should work freely yet remain steady when using the other adjustments. The coarse focussing should move smoothly without backlash or lost motion in turning, and not stiffly. The slides should work without the slightest shake, and if there is no means of adjusting them, the slightest looseness will condemn the instrument. The same smoothness and absence of backlash must be looked for in the fine adjustment. In looking through the lenses, any fine object having thin hairs is a good rough test, and the image should be free from colour fringes and define clearly and sharply.

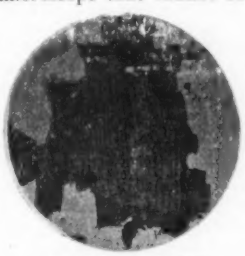

FIG. 3.—BIOTITE.

As the petrological microscope is essentially an ordinary microscope with additional equipment, it must be provided with certain important extras. The founder's microscopic business, however, being two-fold, *i.e.*, metallurgical, or the examination of metals, and petrological, *i.e.*, the examination of moulding materials, it is best to procure an instrument applicable to both sections, which is easy to arrange if considered before purchasing. An instrument which is very suitable for the foundryman, and one which the writer has used extensively, is Messrs. Watson's "School of Mines" petrological microscope, as shown in Fig. 1.

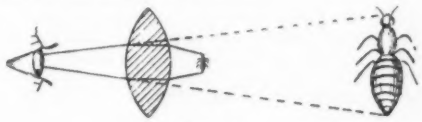

FIG. 4.

It must be provided with a polariser *a* (a piece of apparatus for giving polarised light), below the concentric stage; an analyser *b*, a piece of apparatus for analysing the rays of light after they have passed through the polariser and transparent section placed between the objective and the eye; a concentric stage *c*, rotating about an axis which is in the line of sight of the microscope; and a reflector *d*, which is fitted with a plane mirror on one side for use with daylight, and a parabolic mirror on the other for artificial illumination at night, in order to make the rays of light as nearly parallel as possible.

The polariser, fitted with divided circle as shown at *a*, Fig. 1, is in most cases a nicol prism set in a suitable frame and constructed as follows:—For the nicol prism a cleavage rhombohedron of calcite (the Iceland Spar variety is universally used in consequence of its greater transparency) is used, having four large and two small rhombohedral faces opposite each other. In place of the latter planes, two new surfaces are cut making angles of 68 deg. (instead of 71 deg.), with the obtuse vertical edges. These then form the terminal faces of the prism. In addition to this the prism is cut through in the direction H, H, Fig. 2; the parts are then polished and cemented together again with Canada balsam.

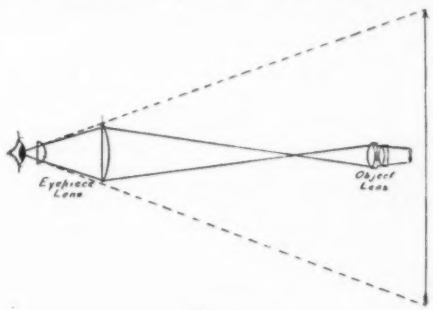

FIG. 5.

A ray of light *a*, *b* (Fig. 2) entering the prism is divided into two rays polarised at right angles to each other. One of these, *b*, *c*, on meeting the layer of balsam (whose refractive index is less than that

of the ray *b*, *c*) suffers total reflection, and is deflected against the blackened sides of the prism and extinguished. The other, *b*, *d*, passes through and emerges at *c* a completely polarised ray of light—that is, a ray with vibrations in one direction only, and that the direction of the shorter diagonal of the prism. The vertical plane through the shorter diagonal may be called the plane of vibration of the nicol, and it is convenient to assume the vibrations of the polarised light as taking place in this plane. The polariser, which is, of course, below the concentric stage, is generally adjusted so as to have its plane of vibration parallel to the east and west cross-wire in the eyepiece (*e*, Fig. 1). German and American practice is usually north and south.

It is important to know the direction of the plane of vibration of the polariser or lower nicol in order to determine when adsorption of light occurs in a mineral, the direction in this mineral parallel to which the adsorbed rays are vibrating. The polariser slides in an outer shell or frame, and by means of a screw can be easily raised or lowered. A convenient test for the location of this plane of vibration of the polariser is as follows:—Make use of a section of Biotite, cut at right angles to the basal plane, hence showing the basal cleave cracks. This mineral Biotite has the property of absorbing to a marked extent the light vibrating parallel to these cleavage cracks (see Fig. 3). Rotate such a section on the stage of the microscope until the position of maximum darkness is reached, and when such is the case the plane of vibration of the polariser must be parallel to these cleavage cracks. On the top of the nicol is placed the condensing lens for getting convergent light, and the adjustments are so arranged that when the nicol is up as far as it will go, the condensing lens is brought almost in contact with the lower surface of the transparent section resting on the stage. Of course, the condensing lens must be removed when very low-power objectives are used.

The concentric rotating stage (*c*, Fig. 1) is supported on a suitable frame, and so arranged that its axis of rotation coincides with the line of sight of the microscope. The periphery of the stage being graduated by means of an index fixed to its frame, angular rotation can always be obtained.

The objectives or lenses screw into the collar of the instrument (*f*, Fig. 1). It might be an advantage to explain the difference between the functions of a simple lens and an objective or microscopic lens when compounded with the ocular or eyepiece. With a simple magnifying glass or hand lens, there is no real image, because the object itself is seen; but the lens changing the direction of the light rays from object to eye, causes the latter to receive them as though they (*i.e.*, the rays) came from a larger object, and therefore every part of the object becomes to our perceptions as though it were enlarged accordingly (see Fig. 4). The microscopic system, however, consists of two stages of lenses, so arranged in exact alignment that the image formed behind the front stage or system of lenses, termed the objective, is thrown into a position from which it can be viewed by a second stage or system of lenses, called the ocular or eyepiece. Fig. 5 shows the part the eyepiece and objective lens plays in performing their work; a single ray of light from each end of the object is represented for simplicity, though it must not be forgotten that a bundle of rays equal to the aperture of the lens proceeds from each and every point in the object, as a cone of rays, and these are condensed as another cone of rays to the corresponding point in the resultant image.

The rays cross on their way (just as light can pass through light without mutual disturbance of any of it), then reach the eyepiece where the inner or field lens bends them in again, and the image is formed in the air between the lenses of the eyepiece. Passing on through the outer or eye lens their direction is again changed, so that the whole bundle can enter the pupil of the eye, which it does in such a direction that the eye sees it as a whole image. Therefore in a microscope an enlarged object is not seen, only an image of it.

The ocular, or eyepiece (*e*, Fig. 1) fits into the top of the draw tube of the microscope, its function being to collect light from the objective and resolve it into an enlarged image of the object. It usually consists of two lenses arranged with their convex sides downwards; the lower lens called the field lens condenses the light and brings the image into the field of view of the top or eye lens, so that the eye can receive it.

As it is proposed in future chapters to describe and illustrate a complete set of apparatus for use in examining moulding materials, no further reference to microscopic detail will be necessary here beyond reference to the microscopical and optical characters of minerals found in moulding sands.

Light may be defined as being transmitted in straight lines by vibrations of the ether, taking place at right angles to the direction of transmission. Ordinary light, however, is light with the ether vibrations in all possible directions, the path described by any particle of ether constantly changing. Plane polarised light is simply light with the ether vibrations all parallel to one plane passing through the direction of transmission. Experiment proves that there exists a very close relation between the optical properties of crystals and their other physical properties, such as colour, form, transmission of heat, etc. Therefore it is often possible by a careful optical investigation of a crystal section to determine important crystallographic facts, even in the absence of any distinct outline.

(*To be continued.*)

Star Antimony.

We have examined lately a sample of the guaranteed 99.70 per cent. Star antimony, which is made at the Smelting Works, Pitsea, Essex, of the Syndicate of London, Limited, whose offices are at Norfolk House, Norfolk Street, Strand, London, W.C. A certificate of assay accompanied the sample, which gave a result of 99.77 per cent. purity, which certificate specifically refers to the quality of metal the Company were making in January last. We mention this because we understand that the antimony which the Company are now making is even purer than 99.77 per cent. Samples which are being submitted to users and merchants, are considered so pure that doubt is sometimes expressed as to the Company being able to execute orders equal in purity to the samples. This in many instances has given the Company an opportunity to receive and execute sample orders on a guarantee of a minimum purity of 99.70 per cent. The ingots are sold under the brand "A." At present the new Company are completing their plans to add 40 new furnaces to meet the growing demands for "A" brand, and to enable them to guarantee regularity and promptitude in delivery. The Syndicate of London, Limited, whose principal business is that of financiers, have taken up the secret process for the manufacture of this special brand of Star antimony, and intend to develop this branch of refining as well as specialise in other branches, particularly in the refining of auriferous antimony ores and concentrates.

Electric Furnaces in Iron and Brass Foundries.*

By E. Kilburn Scott, A.M.Inst.C.E., M.I.E.E.

The electric furnace has hitherto chiefly come under consideration in the metallurgical world in connection with steel refining, ferro alloys, or smelting ores, and but little attention has been given to its applicability in connection with brass and iron founding. In fact, most electric-furnace makers do not care to discuss the application of their apparatus for this work, as it is generally held that the cost of operating is prejudicial to success in competition with the present forms of melting furnaces. While at first inspection and under most conditions this

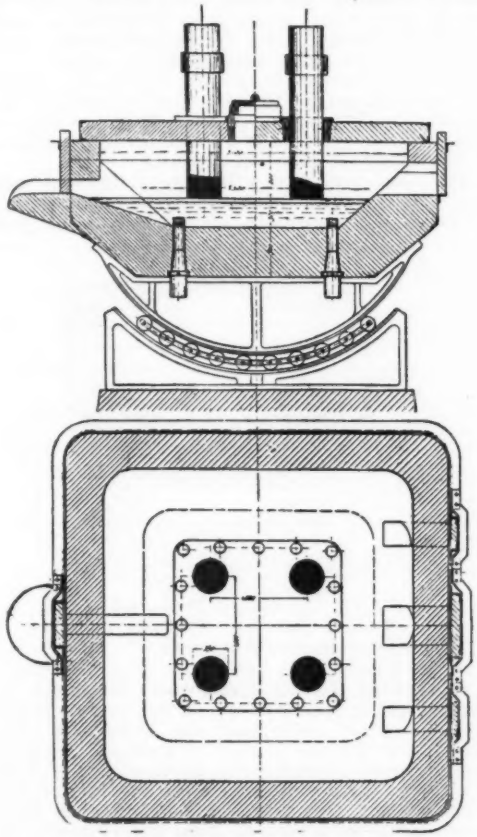

FIG. 1.—THE GIROD ARC FURNACE.

is correct, there are possibilities in front of the electric furnace as applied to brass and iron melting which call for careful consideration. The writer proposes not so much to contend for the general adoption of the electric furnace for this work as to indicate its suitability for special work and the lines along which its development may be expected to proceed. An endeavour will also be made to indicate the lines on which a successful furnace should be designed.

* British Foundrymen's Association Convention Paper.

The descriptions of furnaces hitherto published have been mainly by persons interested in some particular furnace, and have hence been tinged by an unconscious bias. For the present purpose it will be well to first review briefly the features of a few typical furnaces of different types.

Types of Furnaces.

Electrical apparatus can be designed very accurately, because the formulæ used are more fundamental than empirical. Electrical engineers can thus predetermine very accurately what such-and-such a design will give. It is not so much that electrical engineers are very scientific, as that things electrical have the happy knack of doing what is expected of them. Knowing exactly what is wanted and how present processes are carried out, there is very little "hit and miss" experimenting.

The principle on which all electric furnaces work is the passage of large currents over and through, or

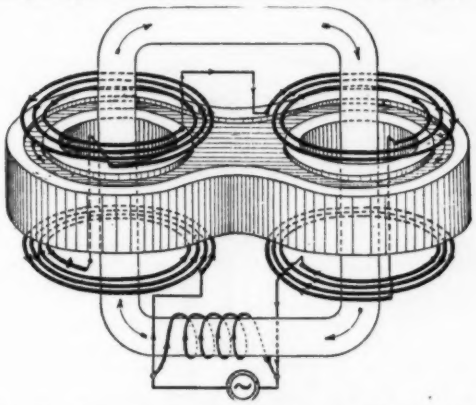

FIG. 2.—DIAGRAM OF CONNECTIONS FOR TRANSFORMER FURNACE.

merely through, the charge. The distinction lies in the method of passing the current through the furnace. Furnaces may be divided broadly into:—(1) Arc Furnaces; (2) Induction Furnaces; (3) Ordinary Resistance Furnaces; and (4) Pinch-effect Resistance Furnaces.

Arc Furnaces.—In the arc furnace the current flows inside the furnace chamber from one carbon electrode to another, either directly through a small air-space which intervenes between the electrodes of opposite polarity in the same way as in an ordinary arc lamp, or indirectly from one electrode through the slag and metal bath to the other. Fig. 1 shows a cross-section through a Girod furnace, which is of this type.

Induction Furnaces.—In the induction furnace first invented by Mr. S. Z. de Ferranti, the heating current in the bath is not the actual supply current. It depends on the principle of the alternating-current transformer, and a transformer core is incorporated with the furnace, so that the metal bath forms the secondary circuit. The primary coils of the

transformer, which are on the cores of the transformer, are connected to the supply terminals. The current which produces the heat in the body of the metal is thus *induced* in the charge, and is not conveyed to it from the source of supply. Fig. 2 shows the electric connections for an induction furnace.

Recent improvements have been in the introduction of three-phase working. This is especially advantageous in the induction furnace, because the bath of metal is rotated in much the same way as the moving portion of a three-phase motor is rotated, and this rotation causes the metal to mix. A three-phase furnace has the advantage over a single-phase furnace that the plant is cheaper, in much the same way that a three-phase alternator has a better weight efficiency than a single-phase machine. Another improvement in the induction type has been in combining induction and resistance effects, and for this electrode plates are fixed in the walls of the furnace.

Ordinary Resistance Furnaces.—This type of furnace generates its melting heat by passing current from electrode to electrode through the charge of metal, which by reason of its resistance to the passage of current has its temperature raised very considerably.

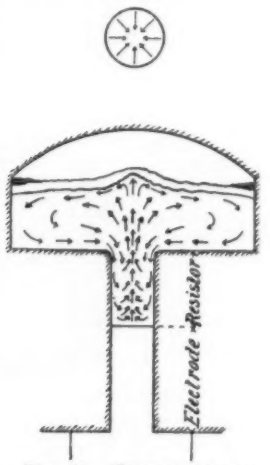

FIG. 3.—CIRCULATION OF METAL THROUGH "PINCH EFFECT."

"Pinch Effect" Resistance Furnace.—A resistance furnace which is distinct in its operation, is that designed by Dr. Carl Hering. Owing to its particular feature and its applicability to the work under discussion, it will be described in closer detail.

In 1907 and 1909 Dr. Carl Hering described in Papers presented before the American Electrochemical Society a peculiar "pinch effect" which he had observed in electric furnaces. It appears that there is a limit to the current which can be passed through a horizontal open channel containing a liquid. When the current reaches a certain amount, depending on the cross-section and shape of the column and on the specific gravity of the liquid, the column is suddenly contracted by electro-magnetic forces until it breaks the circuit. This produces rapid interruptions of the current which prevent a further increase of current and are fatal to the operation of the furnace. Dr. Hering then devised a practical application of this "pinch effect," which he made to serve the useful purpose of rapid circulation.

If a column of a liquid conductor is confined in a vertical cylindrical hole in the bottom of the hearth opening into the body of the liquid and closed at the bottom by means of the electrode, and if a current be then passed lengthwise through it, the effect of the pinch phenomenon will be to contract this column toward its central axis. The liquid will therefore tend to move radially from the circumference to the centre, as shown in the small circle at the top of Fig. 3. These forces, in turn, by hydraulic action, then produce an axial force which will impel the liquid upward and out of the column, while at the same time the suction will draw in fresh liquid around the circumference, producing a circulation about as shown by the arrows. This forces the liquid upward and produces a small fountain.

These liquid columns or resistors, of which there are one for each electrode, are so proportioned that the whole heat for the furnace is generated in them, and the diameter and length are so arranged that the pinching force is sufficient to produce the desired circulation. Each particle of the liquid in turn enters the resistor, where it is immediately highly heated and ejected, being in the resistor only about a second. The cooler material at the bottom flows into the resistor and is in turn heated and ejected. For three-phase current there are three resistors and electrodes. Fig. 4 shows how these resistors or squirting tubes and their electrodes may be applied to the usual type of tilting furnace.

The tubes are lined with electrically-fused magnesite. It is ground into granules, mixed with a binder and tamped into position wet. The joint between the electrode and the wall of the furnace is self-healing, because directly any metal gets between them it freezes solid. In the many furnaces built, there has never been any leakage of metal past the electrodes. It may be mentioned that the co-efficient of expansion of electrically-fused magnesite appears to be about the same as that of iron.

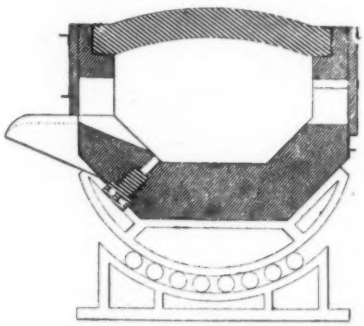

FIG. 4.—SECTIONAL ELEVATION OF TILTING ELECTRIC FURNACE WITH CARL HERING RESISTORS.

The electrodes are usually made of the same metal as the metal to be melted. Thus iron electrodes are used for furnaces for cast steel and cast iron, and copper is used for copper, bronzes and brass.

Comparisions of Furnaces.

Are furnaces have electrodes of carbon which are costly and burn away quickly. They sometimes also break off in lumps, and there is the possibility of wasting away at the sides.

The electrodes require to be fed forward as they burn away, and this requires special gear, and there is difficulty in regulating the current.

There is a difficulty in getting continuous working owing to changing of the carbons, and making necessary electrical connections.

Quite frequently there is trouble in providing for water cooling connections, and a chance of water leaking into the furnace.

The heat is applied at the top of the charge and thus has to travel down by slow conduction and agitation of the charge. Slag at the top may interfere with free working.

The temperature of the arc is frequently greater than that necessary for metallurgical requirements.

The furnace has sometimes to be larger than necessary in order to provide space for the carbons.

Induction furnaces are very expensive, and the design is not convenient from a metallurgical point of view, the electrical gear being a good deal in the way and near to the hot metal.

The transformer must necessarily be inefficient and work at a low power factor unless special arrangements are made to improve the latter, in which case they are an extra expense.

The necessity of retaining a large part of the charge to start the next run, or else preheating the charge, is troublesome.

The temperature is limited by reason of the pinch phenomenon, and thus the maximum temperature may not be high enough for certain purposes.

Owing to the restricted nature of the channels containing the charge there is no large open space for slag action. It is true that additional space may be provided and electrodes added, but they bring in difficulties peculiar to themselves.

The furnace is run up to near the pinching off point all the time. This means very slow starting up, and it is difficult to keep the current steady.

The induction furnace is not suitable for brass because the conductivity of the metal is low and the current becomes so great that the metal pinches. This applies also to aluminium, but to a greater extent, because the metal is so light that it pinches off with quite moderate currents.

The induction furnace requires a low frequency, and this has generally to be given by a special set of apparatus.

Ordinary resistance furnaces exhibit a serious limit of temperature and speed of heating due to the pinch phenomenon.

There is a possibility of contamination of product by the carbon or graphite electrodes.

Great changes in current are necessary as the quantity of reduced material increases.

The slag surface is small, or if this is provided by an additional hearth, there is difficulty in getting circulation from the heating channel to the hearth.

Heat Required.

Before proceeding further to discuss individual furnaces, mention may be made of some general considerations.

The actual heat required for any particular process may be (1) the heat necessary to liquify the raw material from the cold or nearly cold state; or (2), it may be merely that required to raise a charge which has already been liquified, to a higher temperature. Heat may be generated in the charge itself by the chemical changes going on in it. If this change absorbs energy the heat energy represented must be added in order to find the total that the furnace must supply.

If, on the other hand, the chemical change in the furnace gives off energy, then this energy can be subtracted, and only the balance is required from the electric power supply. Of course, many furnace operations are complex, being at one period, say, *endothermic* and then later *exothermic*. In any case the heat units should be added or subtracted as required.

Resistance and Back E.M.F.—An arc is a gaseous resistor, and it is the current passing through this gaseous resistance that enables so large an amount of heat to be generated in a small space. But the arc also produces a counter E.M.F. similar to the back E.M.F. of an arc lamp. In most arcs this counter E.M.F. represents the heat necessary to volatilise the carbon, and if this vapour passes off with condensation or combustion (as for example in a zinc or arsenic furnace) then the heat equivalent that it represents is lost. But if, on the other hand, it burns in the furnace, as indeed is generally the case, then its combustion heat is added to the heat set up by the current passing through the gaseous resistor.

Exact Heat Required.—The arc furnace develops a temperature at the arc which is the temperature of vaporisation of carbon or graphite, or whatever the nature of the electrode may be. Now it happens that most metallurgical processes are carried on best at certain temperatures which do not by any means agree with the temperature of the electric arc. Therefore, if such an arc is used, then excess heat may be wasted through the furnace walls and the electrodes.

Clearly the ideal method of working furnaces is to develop just so much heat and no more, as is actually necessary to carry out the chemical action desired. Such a regulation of the exact amount of heat is possible with induction furnaces and with resistance furnaces, but not possible with arc furnaces.

Transference of Heat.—Furnaces of the arc type produce the greatest heat at the top of the metal, and it has to be transferred by conduction. This also is the method of heating with ordinary regenerative furnaces, but in such case there is special reason for it, namely, carrying a strong oxidising atmosphere over the top of the bath.

In most electric furnaces, however, this is not necessary and, therefore, heating at the bottom of the charge is undoubtedly an advantage. The natural flow of the heated metal upwards then causes active circulation.

Shape and Size of Furnace.

So far as heat losses are concerned, a section of a sphere gives the smallest area from which heat can be radiated. A square-shaped bath is good, and a rectangular shape, which is long compared with its width, is not so good.

As the induction furnace has a very long narrow winding channel, it is the worst shape of all.

The present designs of fuel-heated furnaces represent the survival of the fittest, and therefore the electric furnace design that is as near the present designs as possible, is clearly the best form to adopt.

It is wrong to build a furnace larger than is necessary for the required output, because of the losses by heat radiation. This is especially the case in electric furnaces, because any heat lost has to be paid for as electric power. Generally speaking, smelting processes that are slow, require large furnaces, whereas for processes that are rapid small furnaces are best. Other things being equal, it is better to use a small furnace quickly because it equalises the load on the generating plant.

Let us suppose that a ton of metal is melted in four hours in one case, whilst in another it is melted in one hour, then the radiation loss in the one-hour furnace would be about one-quarter of what it is in the four-hour furnace. As radiation losses are quite a large item in any furnace, this shows the importance of quick melting.

So far as heat loss is concerned, the continuous furnace is better than the intermittent, because in

the latter case the furnace may be standing between the charges quite a considerable number of hours out of the 24. Where a furnace has to stand between charges the heat in it will radiate out through the walls and through the electrodes, and as a matter of fact, it may easily happen that most of the loss is by way of the electrodes.

Electric Energy.

In electric furnaces such as are now under consideration, alternating current is always used, and it may be either single-phase, two-phase or three-phase. For arc and resistance furnaces the periodicity may be any of those in regular use, namely, 40, 50 and 60, but the induction furnace must have a low periodicity. With single-phase, two electrodes are used, and with three-phase three electrodes. Two-phase is rather special, and may be dealt with by having two single-phase furnaces, or one furnace with four electrodes, or still another way is to employ the Scott transformation and change from two-phase to three-phase.

As regards the question of cost of electric energy, the load of an electric furnace affords every inducement to the supply authorities to encourage its development by offering specially favourable terms. It can be a steady all-day load, which is exactly the type of load suited to the central station. Such a load would be similar to a motor load in which most electric supply authorities in industrial centres will supply energy at under one penny per Board of Trade unit (*i.e.* per kw.-hour).

Foundry Organisation.

The foundry organisation may be easily arranged to use the electric energy at other times than the peak load, which is generally in the late afternoon. An ideal arrangement would be to have the electric furnace constantly at work, and keep pouring the metal all day long as the moulds are finished. This would enable a given floor space to turn out greater tonnage per year, and would reduce the equipment of boxes and other tackle necessitated by the common practice of pouring a day's work at the end of the day.

As electric furnaces may be quite small, and therefore portable, the general layout and organisation of a foundry can be improved. For example, the electric furnaces can be on a truck on rails, or it may be suspended from an overhead truck or crane, current being supplied to it by a "cab-tyre sheathed" or other form of trail cable in just the same way as current is supplied to portable electrical machines (coal-cutters, etc.) in mines.

The metal can therefore be melted with the furnace in any convenient position, and the metal poured directly into the moulds. There is thus a saving in superheat; saving in ladles, and heating up the latter; saving in labour.

In Dr. Hering's words, "The ideal plant for a foundry where regular work is done, would be a furnace which contained only about as many pounds of metal as are cast into one flask, and which melted this much metal in the time it takes to move the furnace from one flask to another, and to do the pouring. For small brass castings, such a furnace would be small enough to be readily handled on a track or suspended from a trolley rail, and could be tilted so as to cast directly into the flasks."

In order to show the relative proportions of furnaces, and to emphasise the great advantages of small furnaces, Dr. Hering has prepared the figures given in Table I. The data shows the losses, power, efficiency etc., of furnaces of different sizes, any of which will melt 500 lb. per hour. The hearth is assumed to be hemispherical. The power used, *i.e.* the kilowatts, not the kilowatt hours, for melting is the same for all. The loss through the walls (the total, not that per pound of metal) is the factor which increases rapidly as the furnace gets larger; this is due to the fact that the metal is subjected to this loss for a greater length of time.

TABLE I.—*Different Charges.—Same Rate of Melting.*

NOTE.—Brass. Rate 500 lbs. per hour. Hemispherical hearth. Loss from charge 1 kw. per sq. ft. Electrode loss 20%. Theoretical consumption for melting and 10% superheating of 100 lbs. brass, 8.25 kwh.

Charge in pounds.	Time of melting in hours.	Volume in cubic feet.	Diameter of hearth in feet.	Kilowatts for melting.	Loss thro walls in kilowatts.	Loss in electrodes in kilowatts.	Total power in kilowatts.	Efficiency in percentage.	Kilowatt - hours per 100 pound.
2,000	4	3.70	2.42	41.3	13.7	13.8	68.8	60	13.8
1,500	3	2.78	2.20	41.3	11.4	13.2	65.8	63	13.2
1,000	2	1.85	1.92	41.3	8.7	12.5	62.4	66	12.5
500	1	0.926	1.52	41.3	5.5	11.7	58.4	71	11.7
250	0.5	0.463	1.21	41.3	3.5	11.2	55.9	74	11.2
125	0.25	0.231	0.96	41.3	2.2	10.9	54.3	76	10.9
*	*	—	—	41.3	—	—	41.3	100	8 25

* Imaginary theoretically perfect furnace of infinitely small size, in which 2.000 lbs. are melted in 4 hours with continuous feeding and instantaneous melting.

It will be seen from the last column but one how greatly the efficiency improves as the furnaces are made smaller, also in the last column how fast the kw.-hour per 100 lb. declines as the furnaces are reduced in size. This is important to the user, because that factor represents the power bill.

The Hering Furnace.

We may now revert to a closer consideration of the Hering furnace—the apparatus which appeals most strongly to the writer as being adapted to iron- and brass-foundry work. Among the advantages it presents are the following:—

It is simple and cheap, consisting merely of two or more resistor tubes in an ordinary furnace hearth, a simple electrode being fixed at the bottom of each one. The heat is generated by resistance in the metal in these tubes, and the heating takes place at the bottom of the bath, just where it can be most effective.

The circulation of the hot charge is entirely automatic and in a most effective direction, namely, from the bottom of the bath up to the underside of the blanket of slag.

The speed at which the mixing takes place is such that the charge is treated more rapidly than by other methods. Therefore, for a given size of furnace hearth and given amount of electric energy, a larger amount of material can be dealt with, per day.

The electrodes are of metal and cheap, being usually of the same material as the charge, and they do not consume away, as is the case with carbon and graphite electrodes.

The temperature and circulation of metal may be exactly adjusted to the metallurgical requirements.

Gaseous fuel heat can be applied to the top of the bath without affecting any of the electrical gear. The current can be on all the time or only for the refining or melting part of the process.

All the electrical gear is out of the way on the side and if the furnace is required to tilt, the transformer is attached to it, so that the flexible leads being for high-tension current can be of small section.

Only part of the charge conducts the current, so that the volume of a charge may vary very considerably without affecting electrical conditions.

A much larger amount of energy can be crowded into a given bath of metal than is possible in the induction furnace, because of the pinch effect.

The volatilisation of metal and wear and tear of carbon electrodes characteristic of the arc furnace are avoided.

In the Hering furnace about 10 kw.-hours are required to melt 1 cwt. of brass. This amount of energy at ½d. per kw.-hour is only 5d. per cwt. In the case of crucible melting the cost of crucibles alone is often 5d. per cwt., without obtaining the advantages of the electric furnace as regards control of atmosphere and avoidance of loss by volatilisation and oxidation.

Dr. Hering has developed a brass furnace of the bottom-pouring type, which is shown in Fig. 5. It consists of two hearths, H, H, and two electrodes E, E, with their resistor tubes R. R. At the ends of the hearths remote from the electrodes there are two more resistor tubes, R^1, R^1. These connect together and join the pouring tube P. Four resistor tubes give better circulation, because there are four

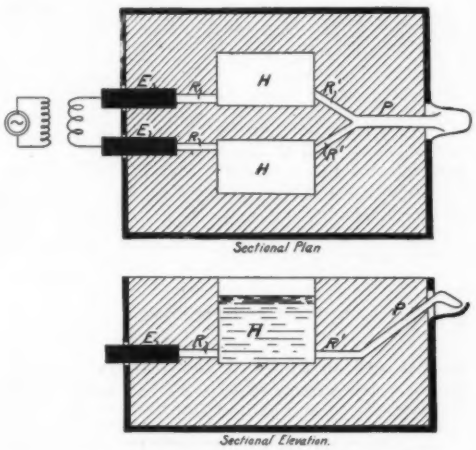

FIG. 5.—HERING FURNACE FOR BRASS MELTING.

squirts and the four being in series each one need not be so long.

As the furnace is of the underpouring type, it always pours perfectly clean metal, and on this account it has been adopted by a large firm of wire drawers, who required absolutely clean metal.

It is very important that the electrodes and the dimensions of the resistor tubes should be exactly proportioned to the work to be done. From the central station point of view, it is important for the two hearths to be near together, as this improves the power factor.

One proposition that came before Dr. Hering was from a firm which was having trouble with sulphur from the coke getting into the cast iron. In order to reduce it they allowed the metal to run off into a forehearth directly it was melted. So a furnace was required to keep the metal in the forehearth melted. In a test that was made it was found that the sulphur was reduced from 0.07 to 0.006 in about one hour, in a Hering furnace, and this quick removal was entirely due to the systematic circulation under the blanket of slag.

Advantages of the Electric Furnaces.

In conclusion, some of the advantages offered by the electric furnace for foundry work may fairly be stated as follows:—

The atmosphere of the furnace may be oxidising, reducing or neutral, the slags may be acid, basic, or neutral, and may be varied to a degree impossible with other ways of working.

The heat may be held as long as desired, in an atmosphere of any required effect, and alloying materials added under ideal conditions that may be maintained.

The furnace takes up little space, and is clean and simple in operation. With the aid of ammeter, voltmeter, and wattmeter, all the operations can be closely watched, and costs obtained most accurately.

The furnace is portable, and can be kept at work pouring metal all day, thus turning out a maximum tonnage for a given floor space and general equipment of tackle, etc.

In ordinary melting processes 40 per cent. of any light scrap that may be fed into the furnace is burned and slagged, and consequently only a 60 per cent. recovery made. An electric resistance furnace is peculiarly suited for the work, as it makes possible a recovery of 100 per cent. in such melting work, with the expenditure of a minimum amount of energy.

With the electric furnace there are many advantages which more than outweigh the difference in cost of heat energy compared with fuel-combustion furnaces. The saving in crucibles and also in zinc lost by volatilisation in brass founding is one important feature, and represents a considerable offset to the cost of the energy. It is well known to brass founders that this zinc loss in ordinary furnaces is often abnormal, and at the best of times is considerable, as evidenced by the fumes given off.

Five per cent. loss means about 1s. per cwt., and in a foundry turning out, say, a ton a week, the loss in zinc would amount to 20s. In addition to the direct monetary loss, the zinc fumes are also deleterious to health, and their removal has to be specially provided for under recent Government Regulations.

The electric furnace has undoubtedly come to stay, and it is of interest to note that the following are some of the better known English firms that have electric steel furnaces at work for steel refining and other purposes:—Vickers, Limited; Wm. Jessop & Sons, Limited: Edgar Allen & Company, Limited; Thos. Firth & Son, Limited; Electro-Flex Steel Company, Limited; and Skinningrove Iron Company, Limited.

In Newcastle ferro-alloys, such as ferro-silicon and ferro-molybdenum, are being made in a 5,000-kw. plant. This plant is of special interest, because the power is obtained from a waste-heat power house using coke-oven gas. The gas raises steam which is used in turbo-alternators, and it is of interest to note that the electric energy is generated at a price that competes with Norwegian water power.

Appendix.

Table I., due to Mr. Ruthenburg, gives the capacity of any furnace in tons of metal, given the current necessary per ton. The formula is as follows:—

$$X = \frac{24\ C}{N}$$

X = Capacity of furnace per day.
C = Electrical capacity of furnace at working voltage (*vide* table).
N = Units (kilowatt hours) required per ton of product.

TABLE I.—*Capacity of Furnaces in Kilowatts: Current Density 50 Amperes per square inch.*

Voltage.	Diameter of Electrodes.								
	3	4	6	8	10	12	16	20	24
60	40	68	150	268	420	605	1,075	1,675	2,500
55	37	62	135	243	385	555	975	1,540	2,300
50	34	57	125	223	350	504	897	1,400	2,075
45	31	51	112	201	315	454	808	1,261	1,850
40	28	45	100	175	280	404	718	1,121	1,650
35	25	39	87	156	245	353	628	961	1,400
30	23	33	75	134	210	303	533	841	1,200

In order that the cost of operation may be readily deduced Table II. gives cost per unit; given the cost of power in terms of horse-power-years :—

TABLE II.—*Power Cost Table*

£ per h.p. year.	£ per k.w. year.	Pence per h.p. hour.	Pence per k.w. hour.
	£ s. d.		
1	1 6 8	0.027	0.036
2	2 13 4	0.056	0.073
3	4 0 0	0.082	0.110
4	5 6 8	0.109	0.146
5	6 13 4	0.137	0.183
7	8 0 0	0.164	0.219
6	9 6 8	0.191	0.255
8	10 13 4	0.218	0.292
9	12 0 0	0.246	0.329
10	13 6 8	0.273	0.365
11	14 13 4	0.300	0.402
12	16 0 0	0.328	0.438
13	17 6 8	0.355	0.475
14	18 13 4	0.382	0.511
15	20 0 0	0.408	0.548

The Vaporisation of Metals.

In a brief Paper on this subject, presented before the American Institute of Metals recently, Prof. Jos. W. Richards remarked that most practical metal-workers know that some metals are volatile, that is, can be evaporated or boiled, but few know the exact facts about the subject. Continuing, he said :—

Metals have vapour tension curves similar to that of water. Regarding water, it is well known that at ordinary atmospheric pressure it boils at 100 deg. C., or 212 deg. F., and that at lower pressures it boils at lower temperatures; at half atmospheric pressure at 82 deg. C., at one-tenth atmospheric pressure at 46 deg. C., and at one-hundredth atmospheric pressure at 7 deg. C. In fact, water can be boiled at any temperature, down to its freezing point, if the pressure over it is reduced sufficiently. A point not generally understood is that an indifferent gas in contact with a volatile substance acts like a vacuum, as far as inducing evaporation is concerned. Water evaporates in a current of dry air at any temperature whatever, the only condition being that the dry air be renewed as fast as it becomes saturated with the water vapour. Even solid water, ice, will evaporate in a current of dry air, although the temperature remains below the melting point of the ice.

All that has been said of water is true of metals. They all have definite boiling points under atmospheric pressure, lower boiling points at lower pressures, and can evaporate at any temperatures down even to their freezing points, if the pressure is sufficiently reduced. They will also vaporise at low temperature in the presence of an indifferent gas, if the latter is renewed as fast as it becomes saturated with the vapour of the metal. It is even true that metals, like ice, have some vapour tension in the solid state, quite sufficient to cause their vaporisation, especially in a current of indifferent gas.

To illustrate this may be cited zinc, which boils under atmospheric pressure at 920 deg. C., but which has an appreciable vapour tension at as low a temperature as 289 deg. C., or 130 deg. below its melting point. Thus, not only will zinc evaporate rapidly when melted in a current of indifferent gas, but even solid zinc can give off zinc vapour. Similar facts are true, although in a smaller degree, of many metals ordinarily considered as non-volatile. Silver, for instance can evaporate from solid ingots which are being heated by direct contact with a flame, the gases of the flame carrying away with them more or less silver vapour, just as dry air can carry off water vapour from ice.

The subject is very large, and the data at hand very meagre, but one practical and important conclusion may be drawn :—Evaporation and volatilisation of metals can best be avoided by melting them out of contact with currents of gases, that is, by heating in closed vessels. This can be accomplished either by melting them in crucibles with covers, or by using electric-furnace heating. The latter is to be preferred, and will be found much less expensive for power than is commonly supposed.

Prof. Richards concluded by expressing the belief that brass can at the present time be melted more cheaply in electric furnaces than by fuel, almost anywhere in the United States, with great saving of the zinc usually vaporised.

A New American Foundry Laboratory.

The new laboratories of the H. M. Lane Company were formally opened by a reception to the Detroit foundrymen on March 23, which was attended by about one hundred people. These laboratories, which are the outcome of the research work which has been carried on by Mr. H. M. Lane during the past twelve years, are located at 18, East Piquette Ave., Detroit, Mich., U.S.A., and occupy some 5,000 square feet of floor space. At the front of the building there are located the general offices and drawing offices, and at the rear of these the chemical laboratory, which is 15 ft. by 40 ft. The remainder of the main building and the adjoining building are given up to the working core room and model foundry plant containing the latest appliances in foundry equipment. The objects of the laboratory are: To study core sands and core binders, so as to find the best mixture for the conditions present in different plants; to study new core binders in order to ascertain their exact value to the foundry; to determine the best method of mixing sands and binders for different classes of cores or molds. A careful study is also made of the proper baking temperatures, baking times, and different core oven fuels. Special machinery is being installed in the laboratory for cleaning and recovering old core sand. In the foundry department there is a melting furnace and appliances for pouring moulds so as to test both the cores and the moulds. A room at the rear of the building is fitted with microscopes and cameras for the study of core problems. A permanent exhibit of apparatus and supplies is also provided and for this purpose Mr. H. M. Lane has had the co-operation of a large number of manufacturers.

The Artistic Treatment of Cast-Iron.*

By B. J. Fletcher (School of Art, Leicester).

In deciding what is the right treatment for any material, several things have to be considered; for example—the nature and structure of the material, the conditions and reasonable methods of working in it, and the use to which the finished product is to be put. It will be found that if these things are properly kept in mind and allowed to suggest a treatment, a sound and reasonable solution will almost invariably be the result.

All materials have their appropriate range. The most unpromising material, if rightly treated within its range, often develops a comeliness and beauty which is surprising. When so treated there is, at any rate, the charm of fitness and appropriateness which is possibly a large part of what we call Art. Strained outside its range, or put to uses for which it is obviously not suitable, a material shows its limitations, is at a disadvantage, and does not properly fulfil the purpose for which it is used. We acknowledge these limitations by writing special music for various instruments, by a restricted and particular range for an individual voice, by a particular type of design for steel construction or for the decoration of tarts. In the straightforward framing and turning of early furniture, the natural shaping and fit ornament of simple pottery, we recognise at once the charm of the material and the appropriate craftsmanship. In the case of cast iron we are rarely made to feel that the material has a unique appropriateness for its use and position; that for the stresses and strains of its office it is perfectly adjusted, and that its robust strength has a characteristic fitness and shaping which is entirely beautiful. The charm of cast-iron as a fine material seldom appeals to us, nor is its fineness reinforced by appropriate design. Most of the errors made in the artistic treatment of cast-iron have been made through neglect of easily recognisable limitations, through attempting a style of ornamental design to which cast-iron cannot possibly do justice.

In the early days of the use of cast-iron, primitive methods of manufacture kept work well within the appropriate range, and it is in this, and in the work done up to about 1840, that we find most fruitful suggestions for proper treatment. A break in reasonable tradition occurred somewhere about the middle of the 19th century, and from the wrong ideas of that period work in cast-iron still suffers. It would be difficult to find any designs more fundamentally wrong than are some of the outstanding works in cast-iron which may be seen among the "Masterpieces of Art" of the 1851 Exhibition. Among these the gates at the entrance to Kensington Gardens are notable examples.

What are the conditions and limitations which should govern the treatment of cast iron? These mainly are:—(1) It is crystalline in structure and is comparatively easily broken by a sharp blow; (2) it has to be run with molten metal in a sand mould; (3) under-cutting should be avoided; (4) where there are large inequalities in sectional area the work is liable to break, owing to varied rate of shrinkage in cooling; (5) smooth and perfectly even surfaces are not easily obtainable as they are in rolled metal; (6) very subtle modelling, which would show in a white plaster cast, is lost through the dark colour of cast iron. Its dark, opaque colour, and a certain roughness and heaviness difficult to avoid, make it unfit for subtle or minute work such as the wrongly praised Berlin metal work, jewellery, or the fruit plates and small ornaments made in England.

The simple bossy richness of modelling seen in old fire backs is both appropriate for moulding in sand and also entirely suitable for casting with molten metal. This bold and broad style of modelling is just that which will tell in dark and heavy metal. It is almost impossible to damage it, and inevitable accretions of soot or blacklead still leave the salient masses of the pattern telling in their places. The evidence of a movable unit of pattern impressed into an open-sand mould with a non-mechanical regularity—evidence of how the work was done—gives these early fire-backs a human quality, charm, and free grace which is quite in keeping with appropriate treatment of the material and its proper use. Through a carefully prepared and accurately finished pattern, other qualities are obtained which are probably necessary when cast iron is to be associated with finely finished work in wood or marble. But it should be noticed that in our later and highly finished work a certain free-hand, generous bigness of handling is absent which seems entirely suitable for the material.

While the figure subjects on these old fire-backs are hardly to be counted sculpture, they are broad and vigorous—they tell their story, often an entirely appropriate one, quite adequately. In one Saint Paul is shaking the viper into the fire. In the back of a grate which Alfred Stevens designed, he put a subject of like appropriateness, namely, Pluto carrying Persephone down into Hades. In this case Stevens, being a master sculptor as well as an excellent craftsman, kept the broad bossiness suitable to the material and position, and, in simple, well-defined planes, carried his modelling further than that of old examples. Such suitable modelling and treatment is seen in the round, and at its best, in the seated lion he did for the low railing which used to be in front of the British Museum. Compact in form and simple in its sections, with well-defined surfaces splendidly simplified yet full of character, it seems made for casting and possibly looks at its best when blackleaded. Stevens modelled several small figures for cast metal in the same compact and vigorous way. In this respect they are akin to the old fire-dogs with their simple block forms and sections and bossy ornament. Egyptian work in hard stones, and some Chinese and Japanese figure work in metal, stone and wood, show the same fine simplification, suggestive modelling and compact shapes. In these there are no pieces to be broken off, no free limbs difficult to cast and core, no difficulties in adjustment of outstanding pieces to be added to the main casting, and no undercutting. Contrasted with these, as an example of what to avoid, we may place a well-known work in cast-iron and a notable 1851 Exhibition piece called "The Eagle Slayer," by John Bell, with its limbs spread and precise sharp and detailed modelling.

In the hob grates of the 18th and early 19th centuries there is much beautiful and appropriate treatmen of cast iron. Little but praise can be given to these grates, for as in other things made for domestic use at this period, their beauty of workmanship and fitting scale for indoor work is entirely pleasing. The difficulty of obtaining pleasing and entirely

* Read before the Association Convention Paper.

satisfactory plain surfaces is avoided by the use of low-relief diaper work, flutings, reeding and delicate arabesques. These are usually well designed and modelled and an adaptation in cast iron of the delicate ornament then much in vogue. Unless this delicate ornament is very carefully cast it loses its character and looks "rotten" and messy. In an example of such work made about 1790 by the Carron Company, the surface is as clean and delicate as a good plaster cast. It is a question how far it is advisable to aim at a cameo-like quality of relief in cast-iron grates, since a grate can only by chance be set in the sharp side light necessary to bring out the detail. Facing from the firelight and not lighted by it, the quality of low relief is lost, and subtlety of surface modelling is soon obliterated by a free use of blacklead. Where ornament of this kind is used for outdoor work the inevitable coats of paint almost obliterate it. The diaper, reeded, or fluted patterns of this period are the most satisfactory as a rule. The uncertain light in which they must be seen, and the inevitable dulling of the pattern, helps rather than degrades the ornament. The simple and straightforward main lines of these early grates; the way in which the ornament is made to acknowledge or emphasise the structural and bounding lines, and relieved with plenty of plain ground make them models of good treatment for cast-iron work for domestic use. The restraint and reticence which these grates show is in strong contrast with the florid outlines and coarse ornament of many modern gas heating stoves.

Between the date of the earlier examples of railing of the baluster type, such as that round St. Paul's Cathedral, and the later delicately reeded and latticed balconies such as can be seen in Piccadilly and elsewhere, there are many good examples of out-door work in cast iron. The early examples are possibly over heavy for their purpose, although after studying them we cannot help feeling how finicking and trivial much modern work is. The scale of this early work is generally in keeping with the building outside which it stands, while our modern work, whatever its merits, too often looks as if it had been designed and carried out by men used to interior work in wood on a comparatively small scale. From about 1750 to 1840 the designers of gates, railings and other castings associated with architecture, adopted an appropriate treatment for cast iron with remarkable success. The treatment is entirely successful in their unpretentious or less ambitious work. In the elaborate pieces the design goes astray through too servile copying of classic architectural detail. In their simpler work much invention is shown in terminals, vases, spear-heads and the like, and variety was obtained by the introduction of balusters and panels at intervals. In much of this unpretentious later work, say for about fifty years from 1780, details directly copied from architectural sources are omitted, or so modified as to be quite appropriate for cast metal, and in this period the straightforward method of casting railings in sheets of lattice of even section was pretty general. The suitableness of this type of design for cast iron is shown by the way in which it has escaped fracture. While much modern work invites breakage, this earlier work still remains for the most part intact. Because of its even section no part is at strain, and, for its weight, it is of maximum strength throughout. Pieces of modern ornamental, expensive and heavy railing may be seen from which all the finials have been broken with probably as much ease and pleasure as icicles are snapt from the eaves.

Much of the poor design of modern cast-iron gates, railings, balusters, crestings and the like is due to a desire to imitate wrought work. The collars, rivets, scrolls and leafage of wrought iron are all imitated, with a result that there are many free ends easily broken, parts difficult to draw from the mould, and difficult to keep free from rust when fixed. "The primary fact in design for casting is the plate plain and pierced, not as in wrought work, the bar or the bent rod in scrolls."

The ordinary lamp-post, piers and pillars of the 1780-1840 period, which are to be seen in London and in many provincial towns, are well worth study. Reticent and light, with a few reeded parts and simple outlines entirely commendable, they seem likely to outlast much later and more abitious work. In out-of-the-way places homely things, excellent in design, such as pumps, foot scrapers and sundials, may be found which were cast about the same time. The inappropriate use of forms borrowed from stone originals is most obvious when seen in association with the framework of engines, machines and metal bridges. The nearer these architectural details are to original classic models, the more evident is their stone origin and the more difficult it becomes to make them answer with any directness to the stresses and strains of a modern engine. Framework or pedestals designed with such detail must be unnecessarily heavy if they are to do their work, and they have the disadvantage of looking unsuitable and of offering many ledges and corners for dust and dirt. The following may be remembered as examples of this ill-advised borrowing:—The "Atlas" press, with its central Corinthian column and acanthus scroll brackets; various girder bridges with spandril spaces covered with Gothic tracery or the like in cast iron. The new Exe bridge at Exeter is of this kind. Even such a scholarly and accomplished designer as Professor Cockerell failed to make correct architectural detail seem fit and appropriate. This may be seen in the large lamp-posts of his design in front of St. Paul's Cathedral. The perfectly-profiled Greek Doric caps which are here copied on a small scale, turned upside down and used as bases, do not suggest cast iron. In the same lamp-posts some cherubs' heads with wings, additions in high relief to the main casting, declare their unsuitability by their broken wings. As a contrast with the detail of these, comparison may be made with the remarkable cast-iron pillar at Delhi, which has stood in the open air for about 1,400 years, and has the dull profiling suitable for cast iron. It may be said that because in several respects stone is similar to cast iron—in its granular structure and its brittleness—it is reasonable to adopt details which have been perfected in stone. Against this it should be remembered that stone detail, when translated into iron, is, as a rule, very much smaller in scale, and in this difference of scale it loses both in its effectiveness and also in its suitability. Its light and shade, which was of primary value in stone, is apt to be reversed or lost when copied smaller in black cast iron. The sharp arrises, naturally developed through joints in masons' work and carvers tools, give sharp edges and corners which cool unevenly with the main casting, and are troublesome to mould. As emphasising this point it will be noticed that Gothic work, which is most characteristically a development of working stone, looks worst when cast in iron. The crisp sharpness of these forms are unfit for a mould of sand and metal none too fluid. At all periods details have been copied from one material to another, but it will be seen that the borrowing has been most successful where the material has transmuted the borrowed detail, and fails most the nearer the copied detail approaches the thing which it imitates. The simple and directly efficient framing and pedestals used with some American machinery are on safe lines, and they

are in some measure artistic. In these, and other well-designed modern machines, the patterns have been very carefully modelled, and the strength and weight put exactly where they are needed. Such castings are as interesting and beautiful as finely-shaped bones, and for the same reason, namely, perfect adaptability of material to use. As "pure form nakedly displayed," they are allied in spirit to Greek Art. From successes in this spirit, the average kitchen range is widely divided, and it should be noticed that its ugliness is largely due to misplaced ornament and lack of clean finish. If the principles of design which are adopted in all that goes to the making of a modern operating theatre, or piece of ordnance, were applied to the design of kitchen ranges, they would be improved both in artistic appearance and efficiency. The heavy and often elaborate mouldings would be absent, badly designed chamfers and diapers would give way to cleaner finish, the often too elaborate name-plate of a maker and ironmonger would go also. The rounding of corners and edges all through would do something towards avoiding casting and contraction troubles, would make for subsequent ease in cleaning, and, as in the softening of the arrises of large and square mouldings, would give character and fitness to the work. With the elimination of numerous ledges, corners and mouldings, the weight would probably be less; it would certainly be easier to cast and to keep clean. As in gates and railings design has erred through imitation of wrought iron, so in pillars and more solid work in the round, the design often goes astray through adopting a treatment suitable for bronze. A style of work which was intended for bronze casting, or which is treated as for bronze, has been imitated from French work, and in one case I know patterns in this style were imported and cast here in iron.

Leaving out of consideration for a moment the original design on paper, the way in which a pattern is made seems almost always to have had too great an influence on the final work. The casting often shows too much evidence of having been made by a worker in wood, and is the outcome of wood and plane, mitres and carving. From what we have seen when considering early castings—the structure of the metal and the methods of moulding—it is plain that the pattern should be more characteristic of the modeller and iron moulder than of the joiner and wood carver. It is in consequence of the joiner's and wood carver's work that sharp internal and external corners come in the mould, and steep walls and crisp edges of sand, which are troublesome to keep slick and sharp in manufacture and afterwards provide lodgment for dirt. Instead of mouldings derived from stone or woodwork, profiles of smoother, rounder sort should be adopted. It would probably be well to eliminate the woodcarver from the ornamental work. The ornament should suggest a clay or gesso—a modelled original. The continued praise which is given to the modelled work of the Brothers Haworth in Messrs. Carron's patterns, and the quality of the modelled designs made by Alfred Stevens for Messrs. Hoole and for the Coalbrookdale Company illustrates this point. The most reticent of the designs which Alfred Stevens made and modelled for cast iron are often admired. It should be noticed, however, that these designs are most successful where they are most obviously modeller's work. In some of his designs the modeller's technique and soft relief of moulded work is well nigh lost through the pattern having been unduly worked on by the chaser, or because the ornament is applied to a polished ground, or to carefully-filed mouldings, or, in other cases, because the ornament is pierced and modelled only on one face.

We must admit that the delicately-moulded and low-relief detail of the hob grates of the 18th century was certainly cast from carved patterns. Some of the original wooden patterns for these are beautifully carved with subtle detail. It is no doubt the low relief, with a wide attachment on to its ground and plenty of plain areas which makes these patterns successful. The same kind of ornament carved sharply in high relief, cast separately and attached with bolts on to a smooth background, such as was in vogue about 1860, clearly shows what is lost through unsympathetic treatment of the material. The detail on the cases of various automatic machines, which are fairly common on station platforms and elsewhere, is, in its low relief ornament, somewhat similar to these old grates, but the two things are, in regard to their artistic merit, as wide apart as they can be. This modern work lacks restraint both in its main lines and also in its ornamentation. Fussy in outline and crowded with badly-modelled and clumsy ornament, the ugliness of these machines is emphasised by picking out their details with colours and gilding. For wasteful hideousness of design these machines are impossible to surpass.

Intricate design in cast iron, requiring an assemblage of small parts cast separately, such as is seen in 16th century Italian bronze grilles and candelabra, is rarely worth while. Apart from the difficulties of unequal shrinkage, fitting, making the moulds and keeping the metal fluid enough to reach outstanding and small parts, the brittle nature of cast iron makes such work inadvisable. Further, it is not possible (except by electro bronzing, which robs cast iron of its own merit without giving it an equivalent exchange) to give to cast iron a surface or texture in keeping with the more delicate character and scale of design suitable for bronze.

Complicated and minutely-modelled figure panels and pictures in low relief, groups of animals on a small scale with sharp detail and realistic treatments of foliage and flowers in full relief, such as are sometimes admired, are examples of clever but wrongly-directed craftsmanship, and are almost invariably of no artistic merit, and not serious design at all. As examples of ill-advised copying of natural forms, the garden chairs of realistic ferns and "rustic" chairs to be seen in many public places will be remembered. Cast-iron fountains made of clumps of realistic bullrushes surrounded with cast-iron water-lilies, painted and varnished, are outstanding examples of what to avoid. From these pretentious vulgarities it is pleasant to turn to the less ambitious but more artistic things often associated with constructional work in which necessity has excluded realistic treatment.

Combinations of cast and wrought iron are rarely successful. The character of the cast part is generally sacrificed in an endeavour to imitate wrought iron. This is most plainly seen where wrought bars are laid in the mould and cast ornament run on to them. The smooth and comparatively true surface of the rolled bars makes the part cast on to them look dull and heavy. Cheap iron bedsteads probably show the combination at its worst. If the metals are to be used together there should be no doubt as to which is which, and their different characteristics should be emphasised. For example: Where in palisading it happens that the posts are cast and intervening lengths of railing are wrought, the sturdiness of the cast newels or balusters of full and ample outlines should be carefully retained and so their generous weight and strength will gain in effect from being contrasted with the lengths of wrought railing which should be obviously attached to them.

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The artistic value of panels of lettering of fine form has yet to be demonstrated in cast iron. Such panels, commemorative of the erection of a bridge, the opening of waterworks or the like, and street names, are, as a rule, noticeable for their ugly lettering and poorly-designed mouldings.

Whether used for interior or exterior work, the surface of cast iron has usually to be protected with blacklead, japanning or paint. Either of these materials, unless frequently cleaned off, completely obliterate delicate modelling. It seems, therefore, only to be taking time by the forelock to make any modelled work broad and bossy in treatment. Easy moulding, and avoidance of parts liable to fracture, also points to this same treatment. For interior work blackleading is better artistically than any kind of japanning with which I am acquainted. For exterior work, which, as a rule, must be painted, grey, white, black or green are good colours. For tramway posts and other cast-metal work of a like kind, which has to stand in the street, grey has the advantage of not showing inevitable splashes of mud and other dirt marks, and in the grey atmosphere of most towns it is almost a "protective colouring." The advantage of using grey may be seen in the painting of the bridges, etc., of the Great Central Railway as it passes through Leicester. Treated in two tones of grey of about the same colour as the clean fracture of iron, the effect is uncommonly good, and these bridges harmonise well with buildings mainly of red brick and slate. The heavy red colour which is often used is ugly, aggressive in large masses, and fails to harmonise with its usual surroundings. Cast-iron posts which stand in a thoroughfare often acquire, through constant rubbing, a surface skin which is entirely agreeable. Cannon, which as trophies sometimes stand outside our public buildings, develop the same surface. In this latter case it is possible that the pureness of the metal has something to do with the good surface.

The necessity for having good designers and modellers for cast-iron work goes without saying, as also that these men must have intimate acquaintance with the material and methods of manufacture. The failure of capable artists like John Bell, Carriere Belleuse, Dr. Dresser and B. J. Talbert to produce work of artistic merit in cast iron shows that something more than facility in modelling and designing is necessary. It is probable that these men had insufficient knowledge of the processes of manufacture and little appreciation of the artistic possibilities of cast iron. The modern designer for cast-iron work has rarely had sufficient training, and has no reasonable tradition to guide him such as that which existed in the 18th century.

In regard to the whole matter of the artistic treatment of cast iron, what is valuable had already been said by Professor Lethaby in a manner at once telling and just, and I need make no apology for quoting him:—

"Work in cast iron should be naturally done; thought of first as use, then as beauty, and never as an imitation. The ornament, whatever it is, must be the surface decoration of a general simple structural form. Repetition is of the very nature of cast work. Repetition of simple elements in different combinations make great actual variety possible, as in old fire backs."

The metal must be both good and carefully manipulated. The design must be thought out through the material and its traditional methods. The pattern must have the ornament modelled, not carved, as is almost universally the case now, carving in wood being entirely unfit to give the soft, suggestive relief required both by the nature of the sand mould into which it is impressed, and the crystalline structure of the metal when cast.

Flat surfaces, like grate fronts, may be decorated with some intricacy if the relief is delicate. But the relief must be less than the basis of attachment, so that the moulding may be easily practicable, and no portions invite one to test how easily they might be detached.

Objects in the round have a simple and substantial bounding form with but little ornament, and that only suggested. This applies equally to figures. In them homogeneous structure is of the first importance.

When possible, the surface should be finished and left as a metal casting. It may, however, be entirely gilt. If painted, the colour must be neutral and grey. "We should aim at leaving the castings untouched from the mould. The Japanese, in delicate kettles and the like, leave the seams on. We should do the same with our bigger objects—we want to proclaim the casting, not despise it.

"In designing we should give up attempts at the artistic; they are apt to miss fire. The thing to aim at is an elegant kind of engineering; straight to the point, simple and honest, not straining the possibilities of the material and processes, but working in sympathy with the material, and taking advantage of its characteristics beauty is created, and foundrymen themselves should be the artists."

Acid Resisting Alloys.

According to "Metallurgie," an alloy which is said to have great resistance to the influence of sulphuric acid cyanide solutions and similar chemicals, is composed of 92 per cent. aluminium, 2 per cent. bismuth, 5 per cent. copper, and 1 per cent. silicon. These metals are melted in a crucible, and molten aluminium added to complete the alloy. Attempts were also made to obtain an iron alloy with great chemical resistance and at the same time soft enough to be worked. Iron-chromium alloys with a very small carbon content were used. The alloy contained more than 10 per cent. chromium, and was refined by adding 2 to 5 per cent. molybdenum. Tests prove that an alloy of 60 per cent. chromium, 35 per cent. iron, and 2 to 3 per cent. molybdenum was of great strength, easily worked, and insoluble in nitric acid, chlorides and even in boiling hot *aqua regia*. Vanadium and titanium gave somewhat similar results. Copper alloyed with cobalt and tin also gave excellent results both as regards mechanical treatment and properties, and resistance to acids. The alloys giving the best results had a composition of 80 per cent. copper, 8 per cent. cobalt, 12 per cent. tin, and 95 per cent. copper, 2 per cent. cobalt, and 3 per cent. tin.

The Solidification of Metals from the Liquid State.

A committee has been appointed by the Council of the Institute of Metals to investigate a problem which may be stated thus:—Does molecular aggregation occur in liquid metals immediately before solidification either by the formation of liquid crystalline units or by the segregation of globules enclosed in foam cells? In a preliminary note on the investigations, by G. T. Beilby, LL.D., F.R.S., it is suggested that while it may not be possible to establish Quincke's view that in all cases solidification is preceded by segregation and the development of a "foam-cell" structure, yet among recorded observations there are some which give colour to the view that at any rate in alloys and impure metals there is segregation under the influence of surface tension in the liquid or the partially solidified state. The more general inquiry as to the changes which precede solidification in metals appears to be a promising territory which is awaiting exploration, and it is to be hoped that the preliminary inquiry which is about to be made into the work which has been done in the various pioneer camps which have approached this territory from various sides will lead to the establishment of new camps within the territory itself.

Some Standard Patterns for Motor Work.*

By J. W. Worrall (Luton).

Before considering the construction of the standard patterns for motor work dealt with in the following notes, it is advisable to refer to various points regarding the castings themselves.

(1) The castings must be regular in size, as most of them, if possible, are machined in jigs—this in order that when they require to be replaced through wear, only the description or detail number requires to be quoted to the works.

(2) The metal must be of the best quality in those parts which are most subject to machining, or are required to possess the greatest strength.

(3) The reduction of labour in the foundry in most cases entails much extra work in the pattern shop, but eventually repays itself by the cheaper castings and quick delivery.

It will, of course, be understood that accuracy is very essential in patterns from which a large number of castings is required.

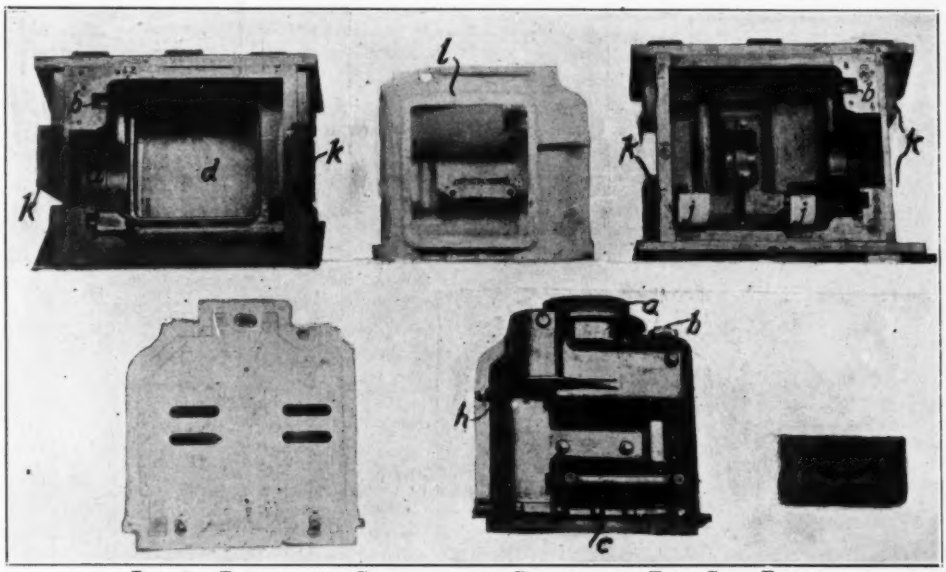


FIG. 1.—PATTERN AND CORE-BOXES FOR BALL-BEARING TYPE GEAR BOX.

Pattern for Ball-Bearing Type Gear Box.

This gear box (see Fig. 1) has one end completely enclosed, with the exception of two round holes, one for the main shaft *a* and the other for the lay shaft *b*. The opposite end *c* is open. The top of the box has a large opening *d* for inspecting and mounting the gears, etc. The pattern is jointed through the centre of the main and lay shaft bearing.

In constructing the pattern two frames (E, Fig. 2) are made, one for each half, framed about 3 in. wide and 1½ in. thick, and halved at the corners. These frames are very important, as they form the foundation for building the cross sections F of the pattern. After the frames are trued and centre-lined, the cross-sections, *i.e.*, the pieces to form the top and bottom of the pattern, are planed true, both sides and one face, of 3-in. mahogany. In this particular pattern the timber should be of sufficient width to allow for pattern and core-box sections to be cut from one piece, thereby saving material. The sections are then marked out to shape (allowing for the frame and also plates G, which are placed on each joint of the pattern), band-sawn and tooled to size, then screwed through the frame, leaving the heads of the screws on the joint side. The plates that are fitted on the joint of the pattern are of aluminium, cast ⅜ in. thick, and planed each side to ¼ in. thick, with recesses leaving the joint facings prominent and about 1 in. wide. The reason for this recessing is to allow for the burring over of the metal caused through rapping.

The rib H and loose bosses I are also of aluminium, the former being fixed by screws and the latter kept in position for moulding by a piece of wire at one end, and a register into the pattern at the other. The prints are made and fixed, leaving about 5 deg. of taper on the ends.

The core-box is made to allow for replacing the parts which get the most wear. For this are first made two walls or boxes to enclose the more important parts. These walls or boxes are of oak, and the ends are registered or rabbeted into the sides, and blocks are fitted on the outside corners to stiffen the boxes, as it is important they should not twist in any direction. They are trued and dowelled together, the joint being through the same centres as the pattern joint. The sections are then cut to fit the box and placed in position. They are then trued across the face to suit the joint line of the outer frame, centre-lined, and taken to be band-sawn and tooled to sizes according to each section. They are fixed in position by screwing through the

* British Foundrymen's Association Convention Paper.

frame or box. These sections can be made of mahogany or pine, according to the number of castings required.

The lay-shaft bearings (*j*, Fig. 1), which are next to be considered, are made of aluminium, with facings on each side dovetailed to the main portion, as they are undercut. These bearings are semi-circular in shape, and have to be withdrawn *with the core* and afterwards removed from the core. They are let into walls or boxes with a good bearing surface to ensure them being placed into the correct position. The core-box is now placed together, and guide-pieces *k* fixed on the outside ends, so that the core is protected when the box is lifted. All parts are then overhauled and varnished. At *l* in Fig. 1 is shown a casting from this pattern and core box.

Fulcrum and Spring Platform Bracket.

This pattern is made to mould in a three-part box, and has five core-boxes. It takes seven cores to complete the mould. The pattern is built in segments up to the centre of the spring platform and turned, leaving a margin of print around the outer diameter (*m*, Fig. 3). Screwed on the top is then a

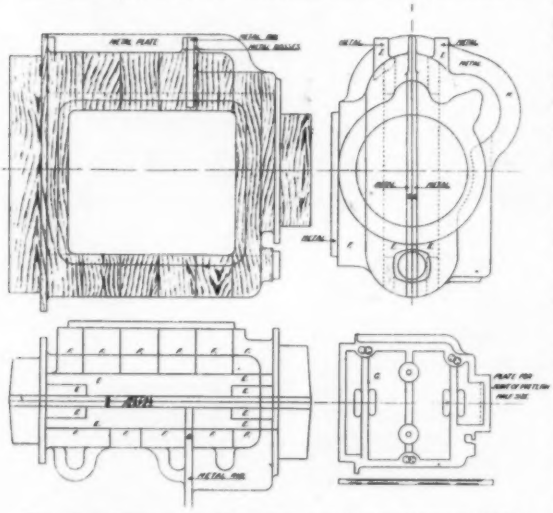


FIG. 2.—SKETCH OF PATTERN FOR BALL-BEARING TYPE GEAR BOX.

block *n* forming the part of platform that will mould and leaving an oblong print *o* for coring round the barrel and under the platform. A recess, turned in the block, takes the register formed in the barrel part. The barrel part *p* is now made and fitted into the block. The beaded part or rim *q* on the end of the barrel is of metal and left loose, having a good sliding fit. The boss on the side is dovetailed on, and a guide *s* for the correct position of the large core is placed on the print *m*. D-shaped prints *t* are now fixed for the bolt cores and the pattern is ready for varnishing.

The large core-box *u* for this pattern is built up in segments, and turned about $\frac{1}{2}$ in. less in diameter than the print of the pattern. The core-boxes are all made with taper to suit the prints. This large core-box is in three pieces:—(1) A large diametrical piece *v* to form the outside shape of the print, with a recess *w* cut in it to suit the guide; (2) a base *x* turned up to give the saucer-like shape of the job; (3) a loose piece *y* registering into the base and having a batten across to dowel into the large ring.

The core under the platform is made in two boxes, *z z*, to facilitate the coreing and also simplify the core-making. The bottom half is cut out of 3-in. mahogany, and the barrel and platform fitted separately. The boss is fixed and registered into the barrel portion, then finally dowelled, forming the top of the box, leaving a space for ramming the core.

Plain Bearing Crank Case.

The design of this case requires two patterns, one each for the top and bottom. The top half (A, Fig. 4) is made with a frame for the base, and the ends fixed to the frame with the body lagged upon the ends. The feet, facings and flange *b*, *b*, are then fitted. The bracket *c* is of metal and fits on to the flange. The end which takes the timing gear *d* is fixed on a large oblong print *e* having about 10 deg. of taper. It is dowelled on the body portion and a sash-screw is used for keeping it in position. A large dummy print is placed over the whole surface slightly larger than the previous print and of sufficient thickness to allow for the timing end and print being drawn into the space it has occupied. This obviates the necessity of a number of loose pieces on this part of the pattern. This method of fixing with sash-screws has proved very satisfactory in practice. The other prints are now made and fixed. The prints for the cylinder holes are glued and screwed. The large print on the base or crank-case joint is dowelled and screwed. This is worth noting, as it saves the bedding-in of the print. The prints and facings for inspection holes are formed in one piece and are dovetailed into the sides of the pattern.

The pattern (F, Fig. 4) for the bottom half is constructed similarly to the top. The core boxes G for the main portion of the top half are made so that the core need not be handled until it is necessary to place it in the mould. The ends are checked into the sides *h* and the sides allowed to extend about 3 in. beyond the outside of the ends, which are $1\frac{1}{2}$ in. thick. This extra length allows for blocks *i* to be screwed to the ends and assists in keeping them true, and also forms seatings for the plates of the sash-screws *j* which pass through the side. There are four such screws, and by undoing them the sides and ends are free to be withdrawn from the core. The timing end core-box K is formed with a 2-in. base and frame built around it to form the shape for the oblong print. The other core-boxes are very simple and have ample timber allowed to take dogs and rapping. The core-boxes for the bottom-half pattern M are similar to the top with the exception of the oil-reservoir boxes L. These are made in a frame and battens placed across the bottom. The block forming the face to meet the main core is then fitted and shaped and screwed in position through the battens. A loose piece *n* is made on one end of each box to form the fillet, and the strickles shape the top of the core.

The core-boxes Q for the feet *b* are made in halves out of $2\frac{1}{4}$ in. mahogany and left open at the print end for ramming. U (Fig. 4) is the front bearing core-box, and the four prints are placed in it for the long bolt cores which pass right through the top half, as shown by prints *v*. The centre-bearing core-box *w* is similar, but has only two prints for bolts. The end-bearing corebox *z* has also two prints for the long cores; the short bosses are drilled. Core-box Y forms the cam-shaft-bearing cores, the three being made in the one box. These are D-shaped to allow for their being placed in position after the main cores G are put into the mould. The core-box Z is for the four cylinder holes, and Z^1 is for the core in the magneto bracket. Z^2 is for the inspection holes, and Z^3 is for the end core in the bottom half of case F.

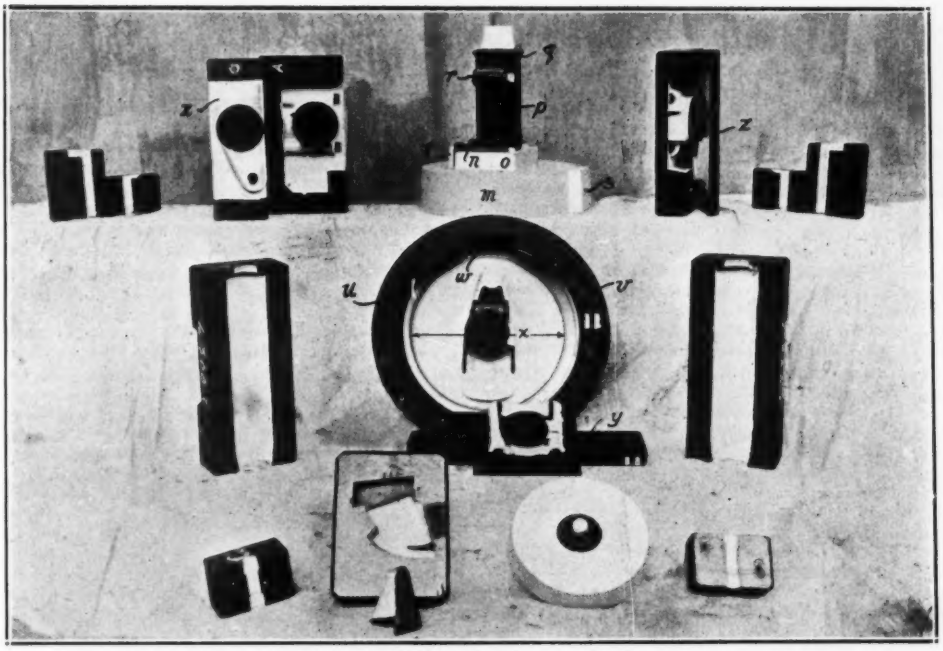


FIG. 3.—PATTERNS AND CORE-BOXES FOR FULCRUM AND SPRING PLATFORM BRACKET.

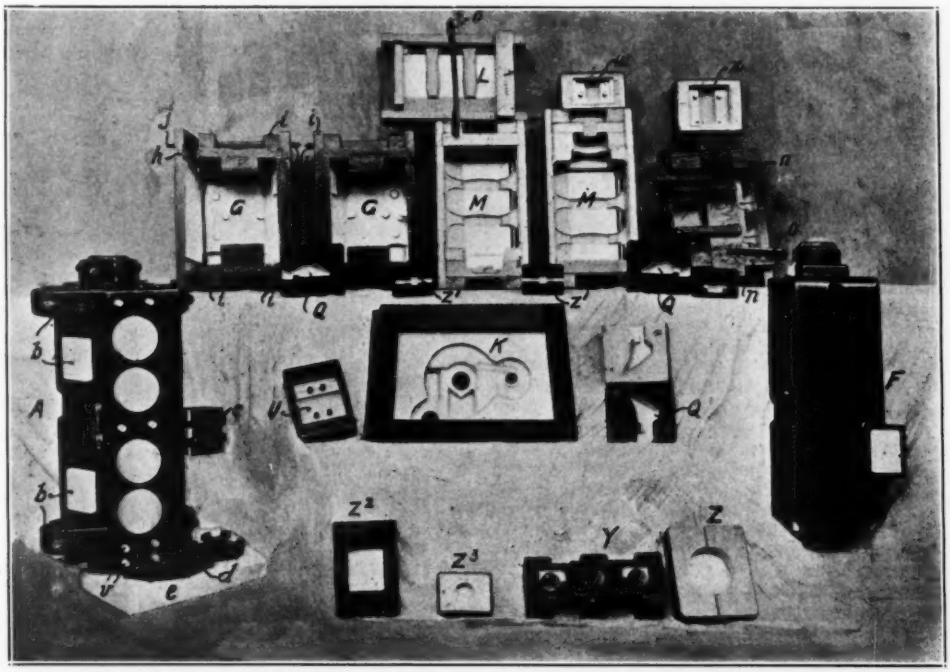


FIG. 4.—PATTERNS AND CORE-BOXES FOR PLAIN BEARING CRANK CASE.

The Foundry Exhibition

At the Royal Agricultural Hall, Islington.

At the Royal Agricultural Hall, Islington, on Saturday, June 14, the First Foundry Exhibition was officially opened by the Right Hon. the Earl of Desborough. The exhibits include foundry plant and requisites from many of the most prominent firms in the Kingdom, and represent the great advances which have been made in recent years in equipment for what is the most neglected branch of the engineering trade. Unfortunately for the Exhibition (though fortunately for those in question) many prominent firms, through the exceptional pressure of business which is now being experienced in the trade, were unable to give the necessary time and attention to exhibiting. Among the firms which from this reason are not represented, we may mention Messrs. James Evans & Company, of Manchester, who were unable to spare the time and men necessary to do justice to the Exhibition. They are, however, represented by the exhibit of core oils and compounds by Petersons National Company, of Philadelphia, for whom Messrs. Evans are the sole agents in this country. Other firms who similarly are not showing include Messrs. J. W. Jackman & Company, Limited, London and Manchester; The London Emery Works Company, Park, Tottenham, N.; James Durrans & Sons, Penistone; Messrs. Piftin, Limited, London; Messrs. Samuelson & Company, Limited, Banbury; Thwaites Bros., Limited, Bradford; Messrs. James Keith & Blackman Company, Limited, and others. Nevertheless, the exhibits on view include many appliances and machines of great interest to foundrymen. We append brief descriptions of some of the exhibits :—

The Adaptable Moulding Machine Company, Bishop Street, Birmingham, have an interesting exhibit of their "Adaptable" moulding machine, the feature of which is its adaptability to pattern plates and moulding boxes of varying size, giving a range from 12 in. to 20 in. in width. This adaptability is obtained by the lateral expansion and contraction of the end frames of the machine by means of a key. In these days of keen competition a manufacturer can ill afford to have machines standing idle, and this must frequently be the case where unadaptable types of machines are installed. Another feature of the machine shown by this firm is its accuracy of drawing the pattern from the mould, this being guaranteed not to vary more than one-hundredth part of an inch in the substantial draw of 6 in. The machine is designed for hand ramming. The table part of the machine is faced to allow for correct stooling, the stools being bolted thereto in cases where it is desirable for green-sand cores to be rammed up and left in the mould. It will be noted that the provision of this stooling device dispenses with dry-sand cores. The working and lubricated parts of the machine are enclosed in cylinders, and are thus entirely protected from either receiving or accumulating any extraneous matter. Rapping, so essentially detrimental to the true drawing of patterns, is entirely eliminated, as the plunger which draws the pattern from the mould, slides in lubricant and is guided by rollers, which renders the operation frictionless, easy, and firm. The withdrawal of the pattern is aided, if required, by the vertical vibration of a spring inside the plunger.

Bleichert's Aerial Transporters, Limited, Egypt House, 36, New Broad Street, E.C.—The chief feature of this exhibit is a large working model of a "Bleichert" aerial wire ropeway. These wire ropeways are equipped with special fixed carrying ropes for the carriers, with a running endless traction rope to propel the cars along the track.

The Britannia Foundry Company, Cox Street, Coventry, have a most interesting working exhibit of some of their latest moulding machines. One of these is the new "Britannia" jar-ram moulding machine which was described and illustrated in our issue of May last. This machine will ram and lift any mould up to 10 cwts. Small boxes may be placed side by side and rammed up together, thus increasing the output considerably. An output of up to 125 complete moulds per 10-hour day, according to the class of article, can be obtained. The construction of the machines being very simple, there is nothing to go wrong as with more complicated machines. The lifting apparatus to extract the pattern from the mould is claimed to be simpler and more accurate than any other on the market. Another machine shown producing moulds is the "Coventry." This machine will mould any casting, however intricate, that can be moulded on any other machine, provided it is not too large to go on the table. Special features are the depth of ram and height of lift. It is a power machine without power, *i.e.*, a patent mechanical geared head enables a man, and without undue exertion, to ram any mould as hard as it is required, and so does away with the expense of hydraulic or other power machines. Other exhibits on this stand are the "Adjustable" moulding machine. This machine is hand rammed with an accurate draw of 8-in., and can be used with any existing pattern plates and boxes; it is instantly adjusted to take any size of box from 8-in. to 22-in. square. On a very intricate job it will be found that a large amount of ramming is of necessity done by hand. For this class of work, where any power ramming is unsuitable, the above machine will be found very efficient. The "Duplex" foundry-sand mixer (Alfred Herbert's patent) is also shown. This apparatus has been described in past issues of our Paper. It will be remembered that it is of the double-cage type and mixes the sand more thoroughly than a single-cage machine. The sand is thoroughly aerated and left light and of even temper, and the cages do not clog. The top hopper has an open bottom and absence of curved or bent passages prevents sand from clogging in the hopper. There is no obstruction in the centre of the cages to the entrance of the sand as on horizontal machines with shafts projecting at each end. All bearings are ball bearings, and all gears are machine cut.

The British Oxygen Company, Limited, Westminster, S.W., give practical demonstrations of oxy-acetylene welding and cutting and show various types of burners and apparatus. The advent of the process of autogenous welding by means of the oxy-acetylene blowpipe dates back to 1901, and although the possibilities of the process for welding and cutting

have been very generously recognised by marine engineers, it has not received that amount of consideration from the general, and, perhaps, more particularly the constructional, engineers which in view of its great utility it certainly warrants. The high-pressure system was the first adopted, and from this numerous low-pressure systems have been evolved. In the case of the high-pressure system the oxygen is used from an ordinary trade bottle, and the acetylene is likewise supplied in the cylinders in the dissolved form at about 5½ lbs. pressure per sq. in. In the low-pressure system the acetylene is drawn from a generator, of which there are many forms upon the market, and the oxygen from a trade cylinder, the oxygen drawing the acetylene into the blowpipe on the injector principle. The temperature of the oxy-acetylene flame is approximately 6,000 deg. Fahr. Both high- and low-pressure systems have their particular fields of operation; thus in a large works where there is a continuous supply of work, the low-pressure plant would be the most convenient, and at the same time the most economical; while in the small workshop, where there are only occasional jobs, or where portability is necessary, as upon constructional work, the high-pressure system is desirable, as quite apart from the facility of handling, it is difficult to adopt a thoroughly effective system of purification with a small portable low-pressure plant. The field of usefulness in welding is mainly confined to steel and iron. Of course, the strength of the weld so produced is frequently less than that of the original metal, mainly because in actual practice it is seldom possible to obtain shearings of similar metal to that operated upon. Cast iron may, by a competent operator, be welded with success, particularly where a good surplus of metal can be added and left on the weld. Copper and aluminium can also be welded, but in the case of the first-named the cost is much greater than that for welding steel, and with the latter welding can only be regarded as an alternative method, and soldering, no doubt, makes a stronger job, whilst with it the risk of cracking and distortion during cooling is considerably reduced. The metal-cutting possibilities of the oxy-acetylene process are almost illimitable. The oxygen supply has sufficient pressure behind it to blow away the oxide as it is formed, thus permitting a clean, narrow cut being made through plates up to 12 in. in thickness at a speed of about 16 ft. per hour.

Carbic, Limited, 27, Cannon Street, London, E.C. —This firm of acetylene specialists have a very interesting display of their oxy-acetylene welding and cutting plants, amongst other exhibits. In this department of their activities all the processes connected with oxy-acetylene work are demonstrated. The efficiency of the oxy-acetylene blow-pipe depends largely upon the freedom from impurities of the acetylene supplied, combined with low temperature and regular pressure. Most authorities agree that the best results so far have been obtained from the use of factory-made gas highly purified and compressed into cylinders for transport; but this process naturally adds considerably to the cost of working. The Carbic generating plant exhibited is specially adapted to meet the requirements for producing pure acetylene suitable for oxy-acetylene blowpipe work. At the same time the plant is so compact that it can be easily transported to the position where the work is to be executed. The smaller plant is fitted with handles whereby the machine can be easily carried by two men, and can also be mounted on a strong wrought-iron bogie, constituting a complete and self-contained apparatus.

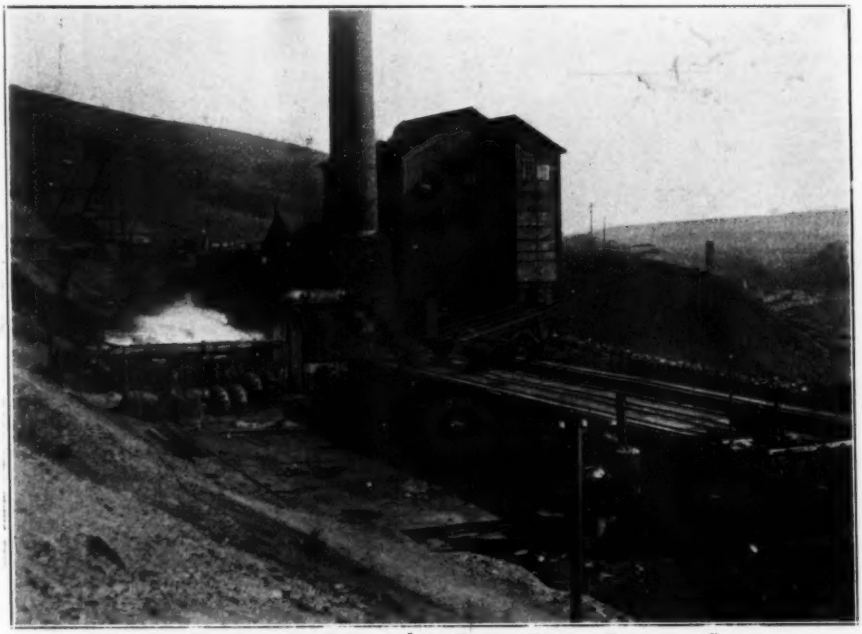


Fig. 1.—View at the Back of the Coppee Coking Ovens at Garth Colliery; Elder's Collieries, Limited.

Elder's Collieries, Limited, Merchants' Exchange, Bute Docks, Cardiff.—This firm of colliery proprietors and coke manufacturers have a fine exhibit of their celebrated foundry coke. As is well known, they are the proprietors and shippers of Elder's Welsh foundry coke, best Welsh large steam

coal, best Welsh coking and steam small coals, best Welsh washed cobbles, and best Welsh washed nuts. Their collieries are the Garth and Oakwood Collieries, Maesteg, Glamorganshire, and their shipping ports are Cardiff, Newport, Barry, Penarth, Port Talbot, Swansea, Briton Ferry, Llanelly and Milford. Elder's Collieries, Limited, are fortunate in being able to produce from their collieries the very best Welsh coking coal from every seam worked, and therefore it is unnecessary for the proprietors to consider the question of separating coals from certain seams for coke-making purposes. Their coking small coal contains: Ash, 5.50 per cent.; volatile matter, 21.50 per cent.; hydrogen, 4.89 per cent.; oxygen, 5.77 per cent.; sulphur, 0.70 per cent. The foundry coke made from this is exceptionally hard; the results of compression tests show a very high breaking power of no less than 1,588 lbs. per sq. in. The ash content on working samples is from 7 per cent. to 8 per cent. The following is a copy of an actual test on Elder's coke made by one of the principal railway companies :—

Total metal melted down.	Coke for lighting up.	Coke for melting.	Coke per cwt. of metal melted.		Pressure of blast in inches.	Time cupolas in blast.	Average metal melted per hour.
			Including lighting.	Excluding lighting.			
cwt. 804	cwt. 14	cwt. 64	lbs. 10.86	lbs. 8.91	ins. 16	hr.min. 3 17	cwt. 244

The numerous users of Elder's foundry coke testify to its exceptionally good quality and high melting power for all descriptions of foundry work, especially so with respect to heavy castings. It is also recommended for light and intricate castings of every description, particularly so with the castings connected with the Diesel oil engines. The fact that it is used by some of the principal foundries in Glasgow should alone be sufficient proof of its value, as the railway tolls and wagon hire to that city amount to 19s. per ton, which has to be added to the prime cost at the coke ovens. We understand that Elder's foundry coke is supplied to the British Admiralty for their foreign as well as home dockyards, and is exported all over the world, particularly to India, South America, Australia and Italy. It is not a by-product coke, but is manufactured in Coppee patent closed retort ovens. An inspection of the coke exhibited will show that it possesses a bright silvery appearance and is excessively hard. Also shown on the stand are samples of the coal from different seams of the Company's collieries. A view of the coke ovens at Garth Colliery is shown herewith. A further illustration shows the way in which the coke is pushed out of the ovens by a moveable ram, and the gases are utilised for driving the colliery boilers.

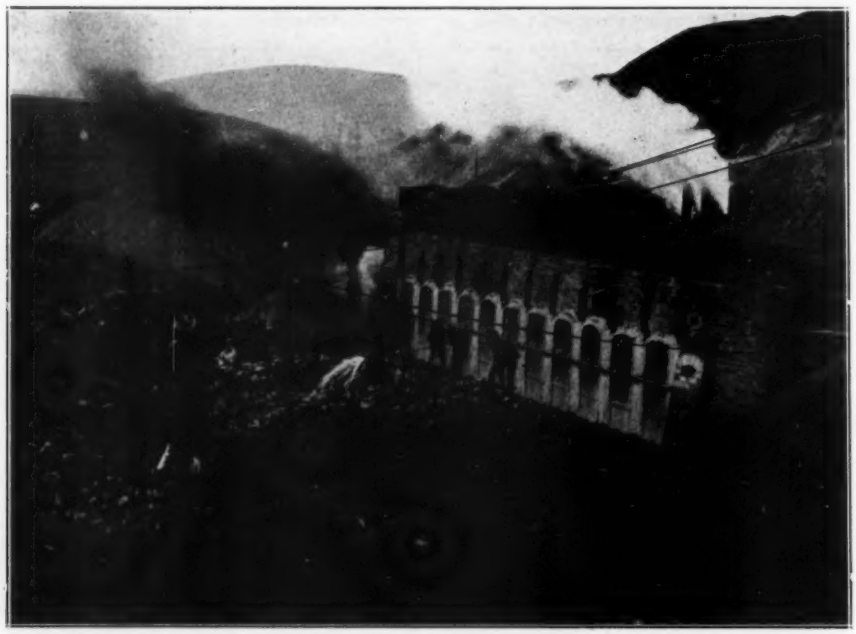


FIG. 2.—COPPEE COKING OVENS AT GARTH COLLIERY OF ELDER'S COLLIERIES, LIMITED. A BATCH OF COKE IS BEING PUSHED OUT WHERE THE SMOKE COMMENCES.

It also shows the road for taking the small coal from the washery after being discharged into small trams.

FLETCHER, RUSSELL & COMPANY, LIMITED, Warrington.—The exhibits on this stand which most interest the foundryman are crucible furnaces. One is a double "Cyclone" gas-fired crucible furnace fitted with a removable base for cleaning purposes. This furnace is specially designed to utilise the waste heat from one melting furnace by heating up a crucible full of metal in the other, by means of the hot flue gas. Another furnace shown is of the portable type to take any size crucible up to 400 lbs. The furnace is fitted with drop bottom for cleaning purposes, and the top is arranged to slide on rails away from its covering position without being removed from the furnace. Other exhibits are a muffle furnace (gas-fired) and small laboratory and other gas-fired furnaces.

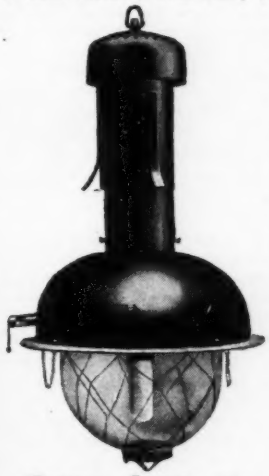
THE FRODAIR IRON AND STEEL COMPANY, LIMITED, FENCHURCH HOUSE, LONDON, E.C.—A neat and artistic stand presents a very interesting representative selection of this firm's pig-irons. Among the irons shown are "Frodair" best cylinder iron; "Norrfield," a tough, strong, general foundry iron; "Bearcliffe," a close, tough, cylinder quality; "C. B. Kittel" cold-blast iron; "Tebruk" charcoal chilling iron; and "L.B.C." cold-blast iron. This firm are well known for their special irons for cylinders, chilled castings, machinery castings, soft and thin cast work, ornamental castings, fire- and acid-resisting castings, and malleable-iron castings.

THE STAND OF THE FRODAIR IRON AND STEEL COMPANY, LIMITED.

The exhibit includes a number of broken pigs and sections showing the fractures of the metal, and also a few small castings which demonstrate the quality of the metal.

RICHARD JACOBSON, 70, SHOE LANE, E.C.—This exhibit includes the well-known "Draeger" self-contained breathing apparatus, Pulmotor apparatus for artificial respiration, and other apparatus and implements for saving life and property, including fire extinguishers, ambulance chests, etc.

THE KITSON-EMPIRE LIGHTING COMPANY, LIMITED, STAMFORD, have an exhibit of their "Kitson-Empire" system of lighting for factories, workshops, etc. This light is of the incandescent-oil class, and is designed to take the place of gas and electricity. We understand that the special adaptability of this lighting system has in some cases enabled it to displace electric lighting and high-pressure gas systems, on account of economy, brilliancy and diffusiveness. It gives a very agreeable light and the least injurious to the eyesight. For moulders' work it is said to be very suitable, for the men can see to the bottom of their moulds with ease, as there is an absence of the black shadows which are common to the electric system. The makers state that the remarkable result of 1,000 actual candle-power at the cost of 1½d. per hour has been obtained by the system. We are informed that the Trinity Board have adopted the Kitson-Empire system for lighting of lighthouses round the coast.



FACTORY LIGHT; BY THE KITSON-EMPIRE COMPANY.

LENNOX FOUNDRY COMPANY, LIMITED, TANTIRON FOUNDRY, GLENVILLE ROAD, NEW CROSS, S.E., is making a good display of "Tantiron" acid-resisting cocks, valves, pumps, evaporators, stills, elevators, pans, basins, compressors, concentrating and fractionating plant, vacuum pumps, etc.

ALEXANDER MARKS & SON, LIMITED, Urswick Works, Urswick Road, Clapton, N.E.—This company have on view an excellent collection of foundry and similar brushes of all descriptions, and also boiler-tube brushes, with both long or short shanks.

MAJOR, ROBINSON & COMPANY, LIMITED, Deansgate, Manchester, are showing "Skolz" iron cement for foundries and engineers; "Skolz" elastic cement for treating the inside seams of boilers, tanks, etc., to repair all kinds of leaks, fractures, boiler patches, etc.; "Skolz" graphite pipe-joint compound for making joints in steam, gas, air or water pipes, tanks, connections, etc.; flange compound for making tight flange joints; and "Skolz" pipe and tube bending machines. The "Skolz" bender is a machine designed for bending in a cold state pipes and tubes for gas, steam, hydraulic, and high-pressure work; and for iron, steel, brass, or copper tubes, etc., without heating or filling. There is also shown on this stand samples of oxy-acetylene welding and cutting, and various small labour-saving devices; also small wheels, gears, pinions, and mechanical movements for various purposes.

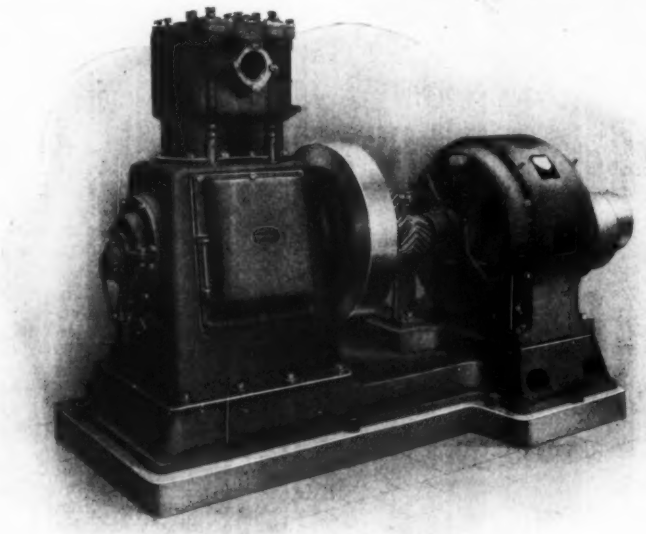
MURPHY, STEDMAN & COMPANY, LIMITED.—This firm have a large exhibit comprising a variety of foundry apparatus and requisites, by firms for which they are the representatives. Among some of the smaller items may be mentioned seamless pressed steel foundry ladles, by Messrs. Joseph Sankey & Sons, Limited; rapping-plates, dowel plates, fillets, etc., by Pattern Requisites, Limited, Birmingham; moulders' blackings, graphite, core gum, chaplets, springs, and a wide range of other requisites, by Messrs. T. Wilkinson & Company, Limited; wax core wire; the "Fortuna" power hack-saw, by the Fortuna Machine Company; the "Battelite" vapour torch lamp for use in foundries; a large core oven, by the Britannia Foundry Company, Coventry; and Woodward's foundry lamp for skin-drying loam and green-sand moulds, drying ladles, lighting cupolas, and also general illuminating purposes. They are further showing a number of the "Caldwell" moulders' shovels,

by the Stockton Heath Forge Company; "Ross" crucible pouring covers; and "Vincit" carborundun abrasive wheels, etc. On a separate stand this firm have installed two of the Britannia Foundry Company's "Adjustable" moulding machines. Also shown on this stand are "Hollis" gap-bed wood trimmers, or universal mitreing machines. These machines were described and illustrated in our issue of November, 1912. Their construction and adaptability renders them almost invaluable in the pattern shop. Among the other exhibits on this Company's stand are plant by the following firms :—

The Best Machine Company are showing on this stand their "Best" core-making machine. This apparatus is of the "plunger" type, but unlike all other designs, it is worked from the front, direct with levers attached to movable links, thus securing a direct vertical lift without any strain. It is provided with a movable vent wire having a vertical motion which leaves the core-box or die absolutely free from obstruction during ramming. After venting the cores, the vent wire is withdrawn, thus leaving the core quite free whilst being ejected from the core-box. With this machine it is possible to change from one size core to another in one minute, and the machine can be adjusted to suit any length of core less than the maximum (9 in.), within the same short space of time. A unique and valuable feature of this machine is that it can be fitted with multiple dies or core-boxes, by means of which any number of cores can be made in one operation.

T. & I. Bradley & Son, Limited, Darlaston, have installed on this stand a representative selection of their warm- and cold-blast pig-irons, including the following:—Warm-blast irons for best engineering castings where softness and toughness are essential; cold-blast irons for obtaining dense castings with a close grey fracture, used extensively for hydraulic work, plough shares, presses, motor work, locomotive, and marine cylinders, etc.; refined irons (R A M and I X L C B R) suitable as a mixture with ordinary grey irons for closing the grain, thus increasing the strength, hardness and toughness (the I X L C B R is well-known for its chilling properties); and refined iron (D M R Charcoal), with which very high physical tests can be obtained as regards the tensile and malleable properties.

Broom & Wade, Limited, High Wycombe, have installed on this stand one of their two-cylinder air-compressors. These machines have a system of forced lubrication which gives perfect lubrication combined with large wearing surfaces. Where possible, case-hardened parts are used, otherwise high-carbon steel is fitted. In no case does the pressure per square inch on the bearings exceed 200 lbs. It is claimed that the volumetric efficiency obtained is higher than is usual in common practice, owing to the use of mechanically operated valves coupled with small cylinders and large cooling surfaces. The amount of air in contact with the cylinder walls of two 5-in. cylinders is 50 per cent. more than with a single-cylinder compressor of the same capacity. A long stroke and a high rotative speed, in which the inertia of the parts nearly equals the compression, greatly reduce the high stress and grinding action often noticeable in air compressors at the end of the stroke. With engine-room temperature of, say, 70 degrees, and pumping against 100 lbs. per square inch, the temperature of delivery will be about 150 deg. to 170 deg., results seldom obtained in any two-stage machine. The compressor is illustrated herewith.

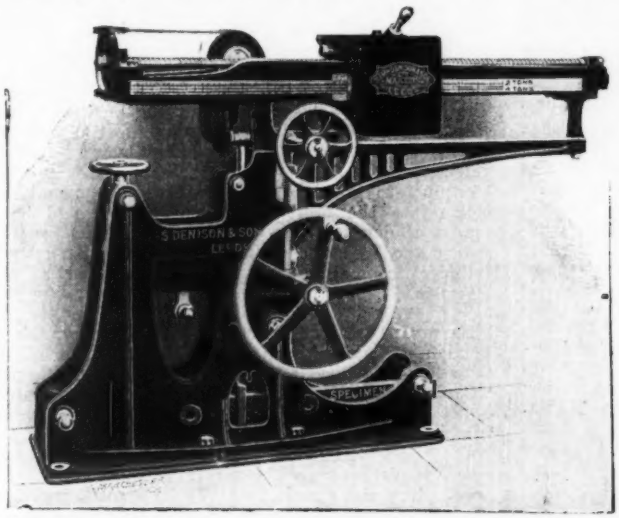


TWO-CYLINDER AIR COMPRESSOR; BY MESSRS. BROOM & WADE, LIMITED.

Messrs. T. Davies & Sons, West Gorton, Manchester, have installed a model of their "Osborn" spark arrester for cupolas, and also a model of one of their well-known cupolas. The spark arrester in question was described and illustrated in our issue of April, 1913. Also shown is an example of their geared foundry ladles, the one shown being of 3-ton capacity.

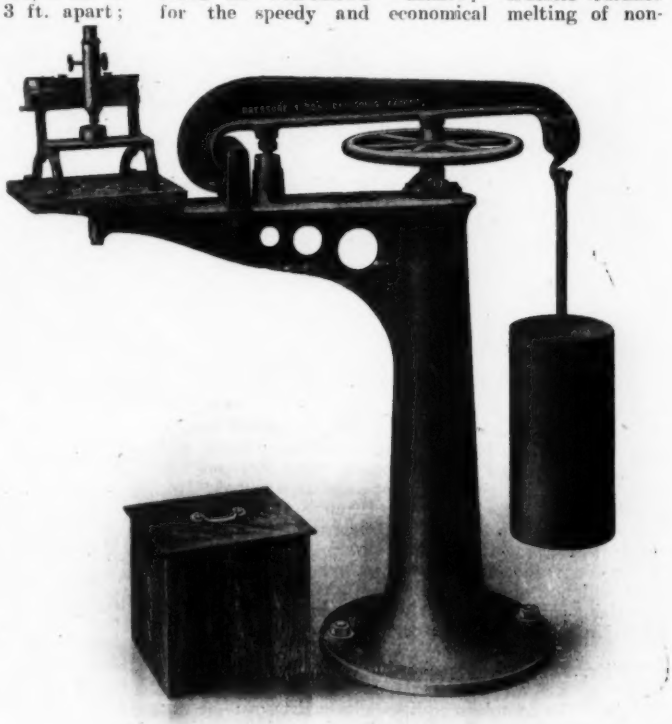
Saml. Denison & Son, Limited, Hunslet Foundry, Leeds.—This firm's contribution to the stand com-

prises two of their testing machines. One, the "Leader" machine, for breaking cast-iron bars, has 2 tons capacity on the transverse test and 4 tons on the tensile test piece of ½ sq. in. This machine is arranged to break cast-iron specimen bars, 2 in. × 1 in., placed edgeway under bearings 3 ft. apart; also bars 1 in. square, under bearings 1 ft. apart. The superstructure of the machine is raised complete by a screw operated by the larger hand wheel, and so pulls up at the centre of the specimen, by a connecting rod. The steelyard, or indicating lever, is graduated by a dividing engine up to full capacity in cwts. by 14 lbs. divisions. The travelling poise-weight is propelled along the steelyard by means of the screw shown, operated by the smaller wheel, and is not touched by the hand. The poise-weight cannot slip forward when the break takes place. The deflection of the specimen is accurately shown on an engraved index-plate. After a test, the poise-weight can quickly be brought back again to zero by its handle, which disengages the nut from the screw. It is to be noted that the machine has no loose weights. There is an accurate extension gauge, and only one pin to move in order to change the machine from transverse to tensile. It is always in equilibrium, whichever kind of test is wanted. The index-bar of the steelyard has two gradations, in cwts., qrs., and lbs., the upper one for transverse tests up to 2 tons, and the lower one for tensile tests up to 4 tons. Messrs. Denison are also showing their new hardness testing machine. This apparatus is illustrated herewith. The pressure exerted is one ton exactly (2,240 lb. avoir.) and is invariable, producing an indentation by a hard steel ball, measurable to 1,000th of an inch of its diameter. The machine shown is complete with a special detachable microscope—shown in position. The apparatus is invaluable when deciding new pig-iron mixtures, and is valuable also for the examination of iron samples, fractures, etc. The microscope swivels on its seat; the eyepiece has cross-lines, and the whole microscope is traversed across the indentation in the specimen by means of a fine micrometer screw. On the upper portion of the stand is a scale representing the number of turns of the screw, whilst the drum of the milled head records to 1,000th of an inch. The microscope has a rack and pinion focussing motion, a graduated draw tube, and carries the standard R.M. Society screw. A further exhibit by this firm is their "Denison" crane weigher—a handy apparatus for suspending to the crane hook so that metal or other material attached can be weighed accurately. Finally, they are showing examples of borings and turnings briquetted in their "Denison-Korte" briquetting machine, which was fully described in our issue of October, 1912.



THE "LEADER" TESTING MACHINE; BY MESSRS. S. DENISON & SON, LIMITED.

J. Holt, Manchester, has installed on the same stand his well-known "M.R.V." crucible furnace for the speedy and economical melting of non-



HARDNESS TESTING MACHINE; BY MESSRS. S. DENISON & SON, LIMITED.

ferrous metals and alloys. It is made in four sizes, viz.:—To melt 150 lbs., 250 lbs., 450 lbs., and 10 cwts. (1,120 lbs.) of metal respectively. It is self-contained and requires no special foundation of brickwork when installed, and is portable and can be run on rails or carried on crane or runway, as desired, to any part of the works for pouring. One man only is required for the complete manipulation of the furnace, and its working, cleaning, and overhauling are so simple that they can be performed by any ordinary metal-mixer. It is also so designed that there is little radiation of heat, and there are no fumes caused in the foundry whilst melting. The metal is actually under the observation of the operator during melting The crucibles are not removed from the furnace until worn out; consequently chilling is avoided. The construction of the furnace ensures complete combustion without impingement of the blast directly on the cucible. The crucible is not "lipped" for pouring, but is held rigidly in position by key-bricks to the cast-iron spout of the furnace, thus obviating liability to fracture, and increasing the life of the pot. The number of heats obtainable from the crucible varies according to the metal melted. With brass we are informed that from 50 to 70 is averaged, and as many as 85 heats have been obtained

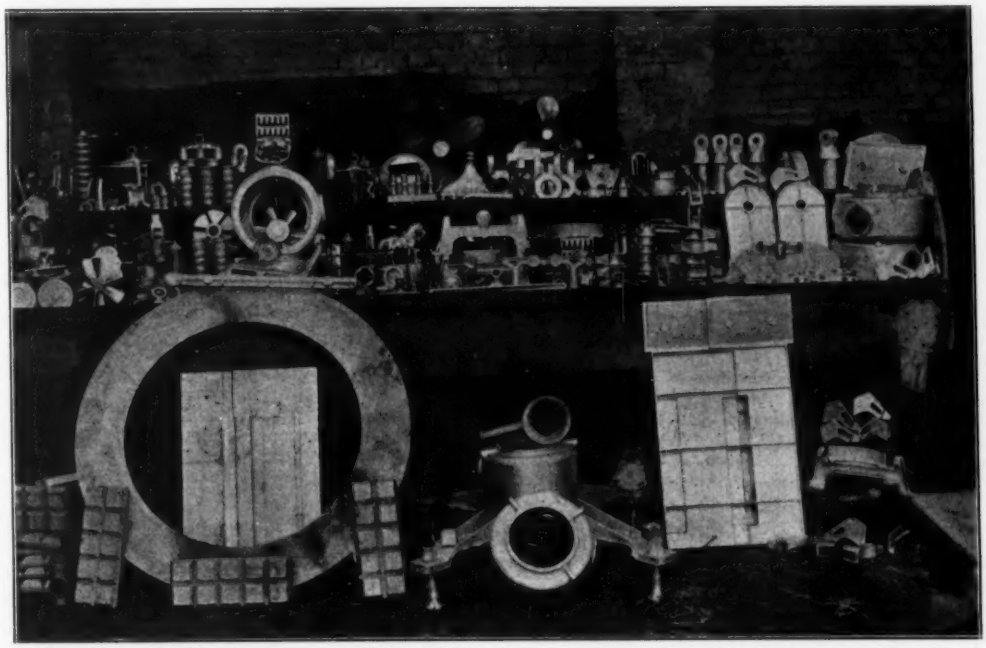
The Mechanical Hammer Company's Blacker's patent parallel hammer, which is intended to dispense with the services of a striker, is one exhibit. The hammer head swings in a radial motion, and thereby can be used successfully for the piecing of hoops, etc., and such things as cannot be got under the head of the ordinary vertical hammer. The motion is imparted to the head by means of two parallel arms by which the head is always kept in a vertical position. This novel feature is the means of allowing any height of tool or thickness of iron to be worked, without the danger of knocking the tool over, and without the necessity of raising or lowering the back ends of the arms to suitable levels. The head of the hammer may also be moved laterally by a very simple and easy motion, thus bringing it to any desired point along the length of the anvil. The weight of blow may also be varied by means of a lever attached to the bottom of the retaining springs, or may be thrown back out of the way almost into a vertical position if required. The hammer is retained in a given position by two compression springs, and is worked by the depression of the footrail around the anvil. One machine shown on the stand is mechanically driven; the other is operated by foot power.

Poulson's Foundry Specialities, Limited, have an exhibit of their patent renovators for the treatment of spent moulding sand; No. 1 for green-sand moulding, and No. 2 for dry-sand moulding, cores and loam. They are highly concentrated compounds, which, when mixed with spent sand in accurate proportions as directed, and put through the sand mill, are claimed to restore it to a first-class facing sand, efficient in application to all classes of ironfounding. These renovators are claimed to be simple in application and not to interfere with the ordinary foundry practice, while also containing nothing injurious or offensive to either touch or smell.

Valite, Limited, are showing, on the same stand, their oxy-acetylene plants for cutting and welding metals. The complete equipment consists of:—Acetylene generating plant; hydraulic safety valve; cylinder of oxygen; oxygen pressure regulator; cutting blowpipe; welding blowpipe; and rubber hose. The "Valite" acetylene generating plant is built of heavy-gauge steel sheets, and is welded at all seams by the oxy-acetylene process, no bolts or rivets being used in its construction. The generators are water-cooled; no overheating can therefore take place under strenuous use. The gas produced is pure, and is twice washed before entering the gas bell. The water feed pipes are straight, and fitted with removable plugs, so that any stoppage due to use of dirty water can be cleared in a moment. The water-feed valve and all moving parts are outside the gas bell; absolute ease in handling and perfect safety is thereby ensued. One of the hydraulic safety valves must be fixed between the acetylene plant and blowpipe, to prevent all possibility of oxygen being blown into the acetylene plant, which would be a source of danger. The oxygen regulator is used to reduce the high and varying pressure in the oxygen cylinder to the constant pressure required at the blowpipe.

National Alloys, Limited, Altior Foundry, Ilford, London, are exhibiting castings and ingots made of their special alloys, which comprise:—"Ivanium," "Capranium" special brass, "Capranium" vanadium bronze, and "Capranium" tantalum. This exhibit is of particular interest alike to the metallurgist, the engineer and the foundryman. The "Ivanium" alloy, which is placed upon the market as a substitute for pure commercial aluminium, calls for special consideration. Engineering science now demands alloys of high tensile strength and good colour, combined with non-corrosive properties. It is well known that pure commercial aluminium has its strict limitations for most engineering purposes, owing to the fact of its being soft, low in mechanical strength, and difficult to cast, and while also not lending itself readily to easy working. It has long been the aim of metallurgists to produce an alloy possessing the undoubtedly good properties of aluminium, but without any of its inherent defects. It is obvious that to be of any real commercial value, such an alloy must compare reasonably well with the pure metal in specific gravity, and at the same time be non-magnetic, tough and non-porous, whilst there must, of course, be an entire absence of electrolytic action between the component constituents. Hitherto, the majority of such alloys, whilst having almost the same specific gravity as aluminium and possessing greater mechanical strength, have, owing to the electrolytic action set up between the component constituents, been of little commercial value. Where tin or zinc, especially the former, is used to form the alloy, exposure to a moist atmosphere will set up a voltaic action with liberation of silicon hydride (when silicon is present as an impurity), a condition which leads to entire disintegration of the alloy in the course of a very short time; whilst in alloys containing magnesium spontaneous deterioration has been known to follow casting. "Ivanium" is the outcome of experiments conducted over a period of years, and although it has now been upon the market sufficiently long to thoroughly test its commercial and practical possibilities, this is, we believe, the first occasion upon which it has been publicly exhibited. It will, therefore, be interesting to briefly refer to its particular properties. "Ivanium" is only 2½ per cent. heavier than pure aluminium, whilst the ordinary alloys are from 10 per cent. to 25 per cent. heavier; its tensile strength (cast) is 11.1 tons per sq. in., or approximately three times that of the pure metal. The weight of a given volume of "Ivanium," compared with a few other metals, is as follows:—Ivanium, 1.00; copper, 3.60; wrought iron, 2.90; brass, 3.45; lead, 4.80. The constituents of which the alloy is composed are en-

tirely non-electrolytic. The colour is silver-like, and the fracture displays a fine silky grain, close and sound, whilst it takes a very high polish, which does not tarnish. It possesses the property of retaining its hardness after being subjected to heat, does not oxidise or become weakened with repeated shocks or vibrations, is unaffected by sea water, sulphuretted hydrogen, sulphides, carbonic acid or atmospheric conditions, and is thus peculiarly suitable for all forms of castings exposed to such influences. "Capranium" special brass, is an alloy containing 60/40, copper and zinc respectively (made from virgin metals), combined with certain of the rarer metals in such a manner as to entirely alter the physical and chemical properties and structure of the brass. It is rich golden-yellow in colour, and produces castings free from blow-holes and of a uniform even grain, which show a regular fracture and have a guarranteed breaking strain of no less than 33 tons per sq. in. with an elongation of 30 per cent. The brass possesses to a very high degree the properties of malleability, strength and resistance to corrosion, whilst it is not affected by heat like other brasses, and can be raised to over 500 deg. Fahr. without showing any appreciable diminution of its strength. These properties make it an invaluable metal for many engineering purposes, such as engine parts and fittings exposed to the heat of steam. Capranium tantalum and vanadium bronzes are, as their names imply, alloys of tantalum and vanadium respectively. These alloys, especially the former, are comparatively new to metallurgy and have not previously been manufactured on a commercial basis, the cost of the rare elements having hitherto precluded their use in other than an experimental manner. National Alloys, Limited, have, however, perfected a process of reducing these elements from the native ores, and have thus placed upon a commercial basis two very valuable alloys which are non-corrosive, cast very fluid, roll, draw, extrude, forge, etc. The ultimate tensile strengths of the alloys range from 50 tons per sq. in., with an elongation of 22 per cent., and give the extraordinary strength of 70 tons per sq. in. when drawn into wire. Such bronzes should be peculiarly suitable for turbine blades and packings, pump fittings for mining and chemical works, etc.



SELECTION OF CASTINGS AND ALLOYS; BY NATIONAL ALLOYS, LIMITED.

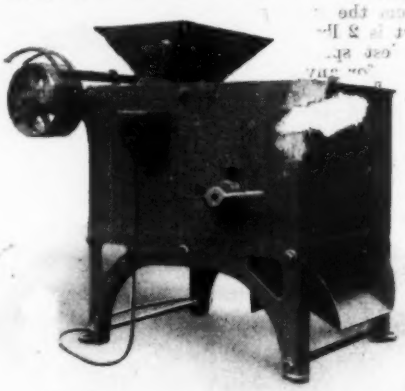
MESSRS. HENRY PELS & COMPANY, Portsmouth Street, London, W.C.—This firm are exhibiting two machines which are of interest to foundries and general engineers. These are of Pels' well-known design, in which the frames are built up of heavy open-hearth steel plates. One is a John's splitting shears, combined with universal punching machine and bar, angle and tee cropper (Type R.B.L.U.E.F.). This type of machine is made in seven sizes, for dealing with plates from $\frac{3}{8}$ in. to $1\frac{1}{4}$ in. in thickness, with corresponding capacity for punch and cropper. The machine on view has a 20-in. gap for the punching end, and will shear plates of any size up to $\frac{5}{8}$ in. thick, flats up to 3 in. by $\frac{3}{4}$ in., will punch holes up to 1 in. diameter through material up to $\frac{3}{4}$ in., will crop rounds up to $1\frac{1}{2}$ in., squares up to $1\frac{1}{8}$ in., angles up to 4 in. by 4 in. by $\frac{1}{2}$ in., tees up to 4 in by 4 in. by $\frac{3}{8}$ in., and other shapes in ratio.

PETERSON-NATIONAL COMPANY.—This Company, whose sole agents in Great Britain are Messrs. James Evans & Company, Manchester, have a very interesting exhibit of their core oil, dry core compound, parting, and "Cortreen." The exhibits also include a considerable variety of cores made from American and English sands, and a few castings and samples of the sand from which the cores and moulds were made. In regard to the four chief features of this exhibit, the core oils shown are recommended as having uniformity of strength and quality, and not gumming and sticking to the core-box; they are

quick in drying, thus saving time and fuel; contain little gas, and thus reduce the tendency to blow; do not crust or "creep" when mixed with sand; make open cores, enabling the metal to lay to the surface of the core; and, finally, are light in consistency, mixing readily with the sand. The dry core compound is valuable for all classes of work in steel, grey-iron and malleable cast iron; it does not gather moisture, will not blow, and does not cause buckling or swelling. The parting has the following characteristics:—It is light in colour and light in weight; takes the water readily; will not stick and allows a clean lift; has no disagreeable odour; works equally well with grey or malleable cast iron, bronze, brass or aluminium, and does not absorb moisture. "Cortreen" is described as a great core-sand bracer, having 150 per cent. the strength of molasses. It is excellent for tempering core sand. The exhibit, as a whole, is of considerable interest, particularly in view of the attention recently being paid to core mixtures and compounds.

C. Portway & Son, Halstead, Essex, have on their stand one of their "Portway" portable core ovens. These ovens are made of galvanised sheets; the whole of the outer case is double and lined with non-conducting material, to prevent the escape of heat. The heat is produced in the firebox or furnace at the base. The air is supplied to the fire through the draught door at the bottom of the front. The air to be heated is admitted by the ventilators on each side of the furnace front, and the interior of the oven is arranged to provide for the circulation of hot air, so that the cores are uniformly dried. There is no risk of over-drying or burning, and the heat can be regulated to suit the particular work. The doors and shelves are easily removable to enable larger cores to be dried if desired. The cores can be put in or taken out of any shelf without disturbing or letting out the heat from the other shelves. A perfectly dry core can be obtained without any moisture left in it in a very short time. Provision is made for the escape of the vapour and gases arising from the drying of the cores, thus insuring that the circulating hot air is always dry. The ovens can be fixed in any position. All that is required is a chimney to which the flue pipe can be connected, or the flue pipe carried direct to the outer air. The ovens consume ordinary coke, or refuse cinders, etc. The fire is under complete control by the arrangement made for admission of air to the firebox. Ovens can be made for heating with gas if required. A selection of cores baked in the oven are also shown on the stand.

W. Silvertseen & Company, 147, Cannon Street, London, E.C.—This firm's exhibits comprise various types of electro-magnetic apparatus, all of which can be connected to any D.C. lighting or power circuit of 110 or 220 volts. Prominent among these are electro-magnetic separators for separating iron parts from foundry sand, slag, ore, coal, non-ferrous metal filings and turnings, or from any raw material and waste. Electro-magnetic separators are now being supplied instead of permanent magnets hitherto in use, which required frequent charging-up. One machine on show is capable of treating about 120 cub. ft. of foundry sand per hour, or about 200 cub. ft. of slag per hour. The driving power required is 1/3 h.p. and 200 watts for exciting the magnetic coils. The magnetic drum is of 12 in. diameter by 14 in. long, revolving at about 25 revolutions per minute, whilst the driving shaft runs at 120 revolutions. A feeding hopper and long shaker are provided for filling and distributing the material to be treated. The framing, as shown in the accompanying illustration, is of cast iron, but there are machines built with steel or wood underframes and of the open or fully-closed types to suit different purposes. The portable machines are supplied with their own motor, generally a small electric motor at the



Electro-Magnetic Separator; by Messrs. W. Silvertseen & Company.

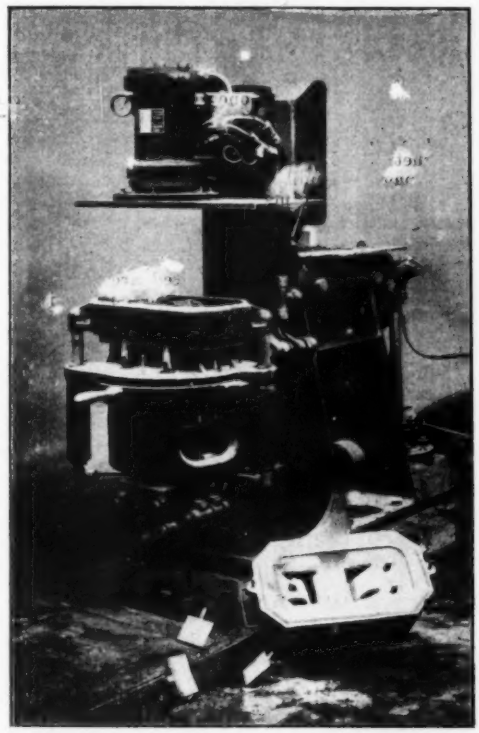
framing. If material has to be treated twice over, as for example, for briquetting plants, two magnetic drums are provided on one machine. Magnetic drums are also exhibited. The 12-in. diameter drum on show gives a good idea of the intensity of the magnetic field and the simple way of adjusting it, the magnetic lift being up to 22 lbs. The many adaptations of magnetic drums in connection with modern foundry and crushing plant of all kinds, using elevators, conveyor bands, etc., will be clearly seen from the varied illustrations in the maker's catalogues. Also exhibit hand magnets. In small foundries where the output is too small for treating samples, these magnets are found of greatest use. They are fitted with a push button and by releasing same the attracted iron particles

Magnet for Extracting Iron Particles from the Eye; by Messrs. W. Silvertseen & Company.

drop off. This type of apparatus is also useful for lifting tools and other iron and steel parts which are awkward to get at by other means, also for lifting hot iron from annealing furnaces or hardening chambers, or for putting iron parts into galvanic

baths. In laboratories for metallurgical purposes for treating samples this magnet is also found of great assistance. A very useful appliance also exhibited is the firm's eye magnet, shown herewith. We are informed that a number of leading [illegible] country are now using this magnet, with very satisfactory results, for extracting iron particles from the eye or hand. The lifting power at the point is 4 lbs., so that they are able to remove the heaviest splinters from wounds. The magnets are wound for any voltage from 4 to 220 volts D.C., the consumption being 30 watts. A number of electro-magnetic blocks of rectangular and circular shape are also on view. These are suitable for grinding, milling, planing, shaping machines, lathes, etc. They represent a great saving in labour in holding up work pieces on these machines and are of great utility for repetition work. The firm make a very large range of sizes from 4 to 59 in. in diameter, and surface plates from 10 in. by 5½ in. up to 63 in. by 16 in. All apparatus are supplied with demagnetising switches, and they are connected by plug to any lighting circuit.

The Universal System of Machine Moulding and Machinery Company, Limited, 97, Queen Victoria Street, London, E.C., are exhibiting some very interesting types of hydraulic moulding machines.



Machine Moulding Railway Chair; by Universal System Machine Moulding and Machinery Company.

Among them is a very ingenious rotary moulding machine of their Type R.5 fitted with a pattern plate of a railway chair. This machine rams the mould without any hand touching, turns over the complete mould, draws the mould, rams the cores in green sand twice (once with ramming plate from the top and once by special pushers from the bottom, so as to give them the required firmness) and vents the cores. All these operations are completed with remarkable accuracy in time varying from 40 to 50 seconds. A feature of this machine is that it works in rough boxes, having a bar in the centre, while the ramming plate is entirely flat and made of a sheet of steel. Another of the Company's moulding machines (Type A.5) is also shown fitted with a pattern plate. An interesting point is that the machine makes automatically 76 vent holes while the runner also is cut automatically on the machine. A smaller machine of the same type is working with a pattern plate of a motor-cycle cylinder and shows the good results which can be obtained by a judiciously designed stripping plate. This firm is also exhibiting one of their recent type of moulding machines for small work, using a double-faced match plate. This machine was described in detail in our last issue. It attracts considerable interest among the visitors to the Exhibition. The sand used on the stand was supplied by the Birmingham Aluminium Casting Company, Limited, Cambridge Street Works, Birmingham, and is sifted on the stand by an electrically-driven sand sieve, built by the Universal System of Machine Moulding and Machinery Company, Limited. All the machines are worked by hydraulic pressure, supplied by hydraulic plant working on the stand, and also built by the Company.

John Williams (Birmingham Sand), Limited, Ickneild Square Wharf, Birmingham, have a good selection of their foundry sands and other products. Their various grades of sand are prepared for moulding for iron, malleable cast iron, brass, bronze, copper, aluminium, German silver, etc. The examples shown include the following:—White silica sand (Bucks.), 97 per cent. pure silica; Coed silica sand; Gornal sand for cupola work; Worcestershire quarry sand for general foundry work, and rolled and prepared for brass castings and core making, and for the moulding machine to obtain a fine skin on the castings; sea (parting) sand; Birmingham quarry sand, as direct from the quarry; Moxley (yellow), for general work; core sand, for brass and copper tube work; and other descriptions of sand. Also exhibited are samples of pure charcoal, plastic ganister (Cheshire), Derbyshire ganister, and limestone (99 per cent. carbonate of lime), broken and ready for use. Plumbago, ladle blacking, and coal dust in coarse, fine and medium grades are further items in this interesting exhibit.

At a meeting of the shareholders of Miller & Macfie, Limited, engineers and boilermakers, Kinning Park, Glasgow, a resolution was passed to the effect that it had been proved to the satisfaction of the meeting that the company cannot by reason of its liabilitiaes continue its business, and that the company be wound up voluntarily. Mr. J. Allison, junr., C.A., Glasgow, was appointed liquidator.

In reference to the Association formed to advance the interests of the makers of tramway and railway material, Mr. J. Sutherland Warner, the first chairman, notifies that among the objects of the Association are Parliamentary representation, organised exhibitions, standardisation of specifications, model clauses for contracts, and the formation of a general council and committee representing the interests of manufacturers. The headquarters of the Association are at the Westminster Palace Hotel, London, S.W.

Inventions.

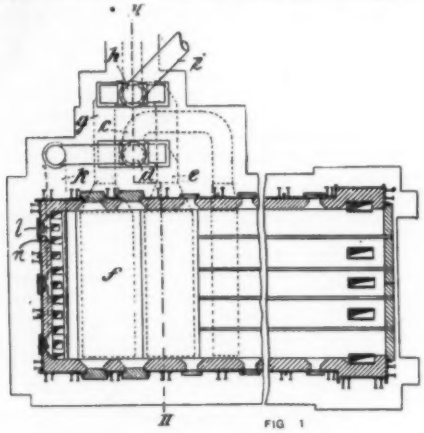
Applications for Patents.

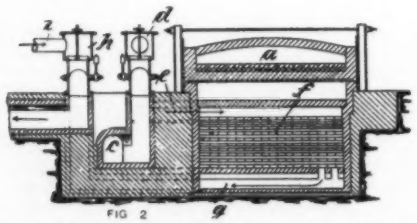
An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

11,370. Steel manufacture. (General Electric Company, United States.)
11,384.*Oil-fired furnace. K. Schmidt.
11,386. Muffle and similar furnaces. August's Muffle Furnaces, Limited, and J. R. C. August.
11,390.*Reverberatory furnaces. Soc. Francais D'Exploitation de fours Speciaux a Haute Temperature.
11,519. Metallic alloys. J. F. Duke.
11,557. Manufacture of steel. F. Rogers.
11,843.*Metal furnace. I. Hall.
11,904. Manufacture of steel. F. Rogers.
12,176. Melting-furnaces of the open-hearth type. G. J. Stock.
12,444.*Electric furnaces. Compagnie pour le Traitement des Métaux et des Minerais par l'Electricité.
12,451. Furnace grates. J. A. Hill.
12,960. Manufacture of iron. A. E. Bourcoud.
12,961. Manufacture of steel. G. J. Boyle and Viscount Chetwynd.

Abstracts of British Patent Specifications recently accepted.

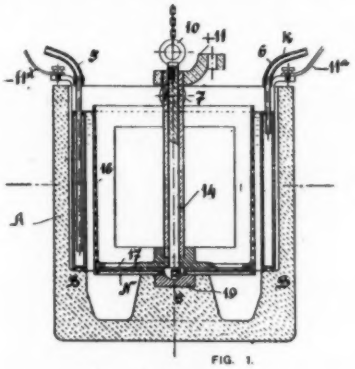
18,148 (1912). *Open-hearth Furnaces adapted for use with Blast Furnace Gas.* The Firm of Poetter, G.m.b.H. 56, Graf Adolf Strasse, Düsseldorf, Germany.—Fig. 1 is a plan of a furnace; Fig. 2 is a section on the line II—II of Fig. 1. The waste gases from the working space *a* of the furnace pass, as usual, into the recuperator *b* arranged beneath it, and are then led through a conduit *c* to the reversing valve *d*. The undue cooling of the waste gases in the recuperator can be prevented by making it comparatively short, whilst by arranging it in front of the reversing valves the burning of these valves can be prevented. By means of the reversing valve *d* the waste gases are caused to pass through one or other of the passages *e* into one or other of the regenerative chambers *f*. The waste gases enter these chambers at the top, pass through them, reach the second reversing valve *h* through passages *g* arranged at the bottom of each chambers and finally arrive at the chimney. The cold gas, usually blast furnace gas, enters through a pipe *i* and then flows through the passage *g* to one or other of the regenerative chambers *f* according to the position of the reversing valve *h*. After passing through this chamber the gas passes to the reversing valve *d*, and thence through the passage *k* to the passage k^1 communicating with the gas ports *l*. The fresh air enters the recuperator through the passage *m* communicating through a conduit not shown, with the arched spaces n^1, n^2 beneath the level of the hearth. Passing beneath the hearth the air, which has thus been heated reaches the air ports *n* through apertures not shown, in the wall n^3.

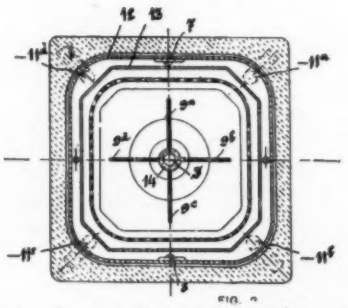




Open Hearth Furnace Adapted for Use with Blast Furnace Gas.

5,855 (1912). *Apparatus for the Electrolytic Refining of Iron.* G. Tischenko, 19, Great Koninshenaia Str., St. Petersburg, Russia.—Figures 1 and 2 illustrate in sectional elevation and sectional plan respectively a type of electrolytic bath in which the anode is surrounded by the cathode. The electrolysis bath consists of a vessel A—A of concrete or reinforced concrete. Inside the bath there are provided projecting parts B—B on the sides, and C at the centre, also of concrete. In the central projection C there is embedded a cast iron block 19 in which is fitted the head 18 of a bolt 14. A cylinder 16 preferably of cast iron or copper is mounted upon the bolt 14, which is arranged co-axially with the cylinder and is connected to the bottom 17 thereof, the outside of this bottom plate being insulated with a concrete layer N. The sides 16 of the cylinder form a grating or are perforated and the cylinder is so arranged in the vessel A that it can be lifted out of the bath by means of an eye bolt 10. The whole cylinder rests on the block 19, and the bolt 18 serves the purpose of centreing the cylinder. On the bolt 14 there is mounted a circular or cross shaped contact device having vanes 9a, 9b, 9c, 9d.

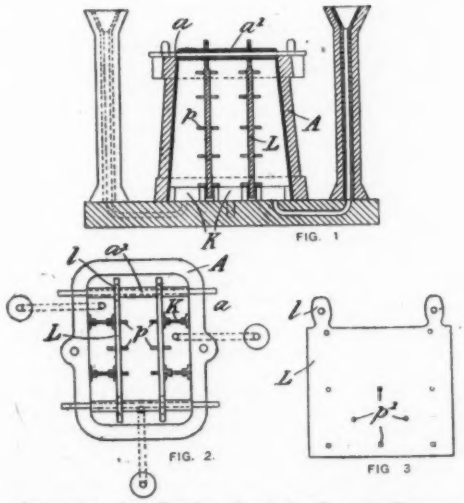




Apparatus for the Electrolytic Refining of Iron.

On the top of the bolt is screwed a terminal 11. This anode cylinder is filled with scrap iron such as turnings, filings, old horse shoes, sheet and plate cuttings and the like constituting the anode proper. The cathode consists of a double walled cylinder 12, 13 supported on the projections B, and is sealed air tight at the top and bottom. On the top of the cathode is mounted the inlet pipe 5 for the heating steam which extends nearly to the bottom. The steam outlet pipe 6 also passes through the top of the cathode cylinder. The cathode is provided with eye bolts 7 and 8 whereby it can be lifted out of the vessel A by means of suitable tackle. At four places on the cylinder are provided terminals 11^a, 11^b, 11^c, and 11^d, whereby the cathode is connected with the negative terminal of the source of current. The anode and cathode cylinders may be made of copper, cast iron, steel, or even wrought iron. In the last three cases the cylinder must be lined with lead or a lead alloy since experience has shown that such perforated anodes can work for many months. When the electrolyte contains alkaline chlorides or carbon compounds the copper may be bare, but when the electrolyte solution contains quantities of sulphuric acid or like substances forming soluble salts with copper, this copper must be lined with lead.

14,234 (1912). *Process for Casting Steel in Several Layers.* Aktien-Gesellschaft der Briansker Schienen-Eisenhüttenwerke and Maschinenfabriken, Morskaja 46, St. Petersburg, Russia.—Fig. 1 is a cross section of a mould for forming the casting showing the division plates in position; Fig. 2 is a plan of the mould and plates; and Fig. 3 is a face view of a division plate. The division plates L, are of such form and lateral dimensions, and are so arranged and supported within the mould, that they are wholly surrounded and covered by the molten metal teemed into the mould, that is to say a small space, for example from 2 to 5 millimetres, is left between all the edges of the plates and the inner surfaces of the sides, top and bottom of the mould A, so that while the plates expand by reason of the heat imparted to them there will be molten metal between the edges of the plates and the several parts of the mould; consequently, when a casting has been allowed to cool



Apparatus for Casting Steel in Several Layers.

no part of the partition plates therein projects beyond the outer surfaces of the casting. The plates, instead of being provided with bond pins p, may have a series of openings p^1, Fig. 3, of small diameter, for example of 2 millimetres, formed in them, through which small streams of molten metal pass for a short distance from a layer on one side of a partition plate into a layer on the other side of the plate, whereby a substantially solid bond between the layers is effected. The plates L are provided with lugs l having openings through which rods a Figs. 1 and 2, pass, the ends of the rods being supported from the walls of the mould. For retaining the plates the proper distance apart separating sleeves a^1 are carried by rods a and distance pieces K are provided at the bottom of the mould.

26,166 (1912). *Tilting Arrangement for Metallurgical Furnaces.* The Jossingfjord Manufacturing Company, A/S., of Jossingfjord, Sogndal in Dalene, Norway.—Tilting regenerative furnaces (Siemens furnaces) were built by Campbell and by Wellman about 1895. In Campbell's furnaces the rockers were supported on rollers interposed between the rockers and the foundation or bed; the two surfaces with which the rollers were in contact forming arcs of concentric circles. A cheaper construction is due to Wellman, whose original furnaces rested on straight tracks. A diagrammatic view of this type of furnace is shown in Fig. 1. The arrangement hitherto employed for tilting a furnace of this type was in the form of an hydraulic ram placed as shown in Fig. 1. This arrangement renders necessary the provision of toothed sectors, which engage with toothed bars in the tracks, in order to give the furnace a true rolling motion. The object of the invention is to provide means whereby the furnace is tilted by a rolling action along a straight track, without employing toothed gearing. The invention consists in providing a metallurgical furnace mounted on rockers rolling on straight tracks, with means whereby the tilting force acts

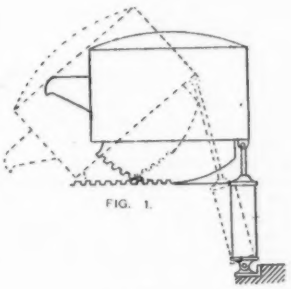
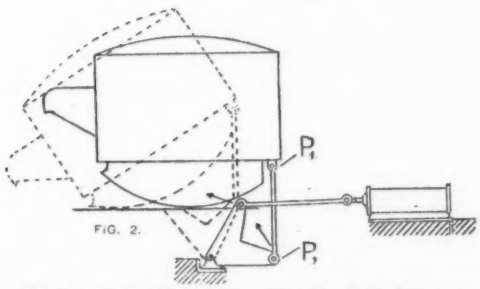


FIG. 1.



Tilting Arrangement for Metallurgical Furnaces.

approximately in a vertical direction during the whole of the tilting operation. A diagrammatic representation of such a furnace is shown in Fig. 2. The application of the tilting force in a vertical direction is accomplished, in the manner shown, sufficiently approximate for practical purposes. The point P_1 moves in a cycloidal path and the point P_2 in a circular path; the lifting force always being approximately vertical if the radius of the circle which P_2 describes is small compared with that of the rolling circle, and if the rod connecting P_1 and P_2 is vertical when the furnace is in its horizontal position.

Trade Talk.

RUSTON, PROCTOR & COMPANY, LIMITED, of the Sheaf Ironworks, Lincoln, made an issue of 100,000 ordinary shares at par (£1).

A FIRE broke out on the premises of Wilkes, Sons & Mapplebeck, Limited, Birmingham, on June 2, but the damage was not heavy.

PETO & RADFORD, LIMITED, engineers, have removed from 100, Hatton Garden, London, E.C., to 12, Heddon Street, Regent Street, London, W.

A FIRE broke out at the engineering works of John Cameron, Limited, Oldfield Road, Salford. The damage was confined to the driving gallery.

THE Barking works of the Atlas Metal and Alloys Company, Limited, 52, Queen Victoria Street, London, E.C., have just been considerably extended.

THE LANARKSHIRE STEEL COMPANY, LIMITED, of the Lanarkshire Steel Works, Motherwell, have removed their London offices to London House, New London Street, E.C.

MR. F. W. ROCK, trading under the style of F. W. Rock & Company, at Church Lane, Wolverhampton, brass founder, has paid a first and final dividend of 3s. 2½d. in the £.

MR. WALTER DEELEY, brassfounder, 28, Holloway Road, Birmingham, who has retired from business, has transferred his business to A. D. Foulkes & Company, Limited, of Birmingham.

MCKINLAY & COMPANY, LIMITED, of the Mile End Engine Works, Commercial Road, Landport, near Portsmouth, have established a branch at 409, Commercial Road, Portsmouth.

JOHN SUMMERS & SONS, LIMITED, of Shotton and Stalybridge, have opened a London establishment at Cullum House, 34, Lime Street, E.C., under the charge of Mr. J. Whitby.

THE creditors of Walter Martin Musgrave, engineer, of Ashleigh, Chorley, New Road, Bolton, are required to send particulars of their claims to Mr. H. Mather, the trustee, by July 10.

THE business of Messrs. James Spencer and Company, Chamber Ironworks, Spencer Street, Hollinwood, near Manchester, has been converted for family reasons into a limited liability concern.

THE ROTHER IRONWORKS, Rotherham, belonging to Owen & Dyson, Limited, were the scene of a fire on June 10, which, owing to the prompt efforts of the brigade, did no considerable damage.

THE creditors of the Carlton Engineering Company, Limited, are required to send particulars of their claims to C. Osborn, 66, Mark Lane, London, E.C., the liquidator of the company, by July 15.

THE business of the St. Pancras Iron Works Company, Limited, has been acquired by the Art Metal Construction Company, Limited, 5 and 6, Holborn, London, E.C., and Silvertown, London, E.

THE partnership heretofore subsisting between Messrs. T. Roddis and W. H. Robson, carrying on business as engineers at Roade, Northamptonshire, under the style of Roddis & Robson, has been dissolved.

MESSRS. BENTON & STONE, brassfounders, of Bracebridge Street, Birmingham, have taken over the business of Messrs. W. Probert & Son, brassfounders, Handsworth Crescent, Hockley, Birmingham.

BARLOW & CHIDLAW, LIMITED, of Pendleton, Manchester, have appointed Mr. T. S. Smith, 5, Idol Lane, Eastcheap, London, E.C., as their London and district agent for machine-cut gears and Woodruff keys.

MESSRS. DOUGLAS & ADAIR, consulting engineers, 1, Fenchurch Avenue, London, E.C., have opened offices in Glasgow under the title of Douglas & MacLeod, and in Athens under the title of Douglas & Kairis.

THE petition of T. & J. Hosking, Limited, for the winding-up of the Vacuum Engineering Company, Limited, has been dismissed without costs, counsel stating that arrangements had been made to pay the petitioning creditor's debt.

THE partnership heretofore subsisting between Messrs. A. H. Laybourne and R. C. T. Laybourne, carrying on business as engineers and ironfounders, at the Isca Foundry, Newport, under the style of the Isca Foundry Company, has been dissolved.

MESSRS. J. OGDEN AND J. C. JACKSON, carrying on business as engineers and millwrights, at Lansdowne Ironworks, Chadderton, under the style of Jackson & Ogden, have dissolved partnership. Mr. J. C. Jackson will continue the business under the present style.

THE firm of A. C. Millar & Company, engineers and ironfounders, Carsehead Iron Works, Dalry, Ayrshire, has been dissolved by the retirement of Mr. J. C. Menzies. The business will continue to be carried on Mr. A. C. Millar and Mr. C. Anderson under the same name.

JOHN MUSGRAVE & SONS (1913), LIMITED, who have taken over the old-established business of John Musgrave & Sons, Limited, have, in addition, purchased the business of Messrs. J. & E. Wood, of the Victoria Foundry, Garside Street, Bolton. Mr. Henry Wood is a director of the new concern.

THE extensive engineering works of Yates & Thom, Limited, Blackburn, have been seriously damaged by fire. The offices, and pattern, moulding and boiler shops were saved, but the machine room was practically gutted. It is hoped to have the main portion of this ready for work in a short time.

IT has been proposed to hold an international exhibition at Manchester within the next eighteen months. A committee was recently appointed to consider the matter, and the members have presented their report to a public meeting called by the Lord Mayor. It was suggested that some time next year would be a suitable period for the exhibition.

A PETITION of Barry, Henry & Company, Limited, for the compulsory winding up of H. A. Harvey & Company, Limited, engineers, Norfolk House, Laurence Pountney Hill, E.C., has been granted, notwithstanding an application by the company, supported by the debenture holders, that it should stand over pending arrangements for dealing with the property.

MR. O. HEEGER, 432, Mansion House Chambers, Queen Victoria Street, London, E.C., has been appointed London export agent for the Soc. Anon des Laminoirs, Hauts-Fourneaux, Forges, Fonderies et Usines de la Providence, Marchienne-au-Pont, Belgium, makers of bars, angles, joists, etc. The company are one of the constituents of the Belgian Steel Syndicate.

THE BIRMINGHAM BRANCH OF THE BRITISH FOUNDRYMEN'S ASSOCIATION had its first annual picnic on Saturday, June 7, when a party of about 70, including lady friends, visited Stourport and Worcester. The visitors travelled by rail to Stourport, and thence by steamer down the Severn to Worcester. The river trip, 12 miles each way, was exceedingly enjoyable, being favoured by perfect weather.

AT the adjourned meeting of the creditors of Mr. F. W. Tannett-Walker and Mr. A. Tannett-Walker, directors of Tannett-Walker & Company, Limited, Leeds, at the offices of the Leeds Official Receiver, composition schemes were submitted on behalf of the debtors, but after lengthy discussion the Official Receiver said he would probably have to report against the schemes, as being indefinite and inconclusive.

THE partnership heretofore subsisting between Messrs. W. Burgoine and A. Burgoine, carrying on business as engineers and millwrights at Croft Street Foundry, Bury, Lancashire, in the name of John Burgoine & Sons, has been dissolved by the retirement therefrom of Mr. A. Burgoine. The business of the late partnership has been converted by Mr. W. Burgoine, the continuing partner, into a limited company, under the name of John Burgoine & Sons, Limited.

THE GREAT EASTERN RAILWAY COMPANY have forwarded a copy of the new edition of their handbook, "On the East Coast," which can be obtained free from the Superintendent of the Line, Liverpool Street Station, London, E.C. In this publication prominence has been given to some less-known district in East Anglia, and to the country between the Cromer and Hunstanton Coast and the Norfolk Broads. The illustrations in colours are

a special feature of what should prove a very interesting guide to holiday-makers

An interesting demonstration has been given in the laboratories of Jonas & Colver, Limited, Sheffield, on the possibility of showing in cinematograph form the crystalline changes that take place during the pulling of a test piece in the testing machine. The new system of testing was the invention of Mr. B. W. Winder, and consists of a specially-constructed testing machine, to which a miscroscope is fixed, connected with a camera, so that not only can the whole of the changes that take place be noted, but photographs can be taken any time during the process. The microscope, which is a specially constructed one, however, can easily be affixed to any ordinary testing machine. The specially constructed testing machine has been designed by Mr. Winder and Mr. Walter Burgan (Messrs. Jonas & Colver's engineer), and has been made on the firm's premises. It is worked hydraulically, the readings being taken on a pressure gauge. The hydraulic power is derived from a new system of accumulator. The whole apparatus, including the pump, testing machine, and accumulator, are all on a small bench, 6 ft. by 3 ft., while the machine is a little over 1 ft. long.

Alfred Hickman, Limited, of the Spring Vale Works, near Wolverhampton, are at present engaged upon extensive alterations and additions which will result in considerably increasing the output of steel, a new open-hearth plant having been inaugurated and being now in regular operation. It consists of a 40-60-ton tilting furnace, which is the first of a range it is proposed to erect. The furnace is served by a Wellman-Seaver charging machine, a 40-ton hot metal crane, and a 75-ton steel casting crane. In connection with the steel-making plant a 500-ton mixer furnace is being put down, and this will be served by Mond producers at present in course of erection. To provide for the additional output of slag, and to make room for the large mixer furnace, Messrs. Hickman are removing their existing slag-grinding plant to another site. The slag plant, when completed, will have a grinding capacity of 1,500 tons per week of Bilston basic phosphate. The new plant is entirely driven by gas-engines using blast furnace gas. Another large gas-engine and dynamo, to provide the additional power required in the works, are being erected in the new power house. The engine is of 1,000 h.p., and its installation will give the gas-power plant at Messrs. Hickman's works a capacity of 14,000 h.p. A briquetting plant for dealing with fine ores is also in course of construction.

The annual general meeting of the British Acetylene and Welding Association was held recently, at the Westminster Palace Hotel. Mr. Ernest W. Sprott was elected president for the ensuing year, Mr. T. G. Allen, vice-president, and Mr. H. T. Baker, treasurer. The President, in his address, stated that during the twelve months the by-laws of the Association had been modified with the object of enlarging its scope, and covering the welding and metal cutting processes which had, in recent years, become so helpful to the acetylene industry. Under the auspices of the Association, welding classes had been started at the Northern Polytechnic. Day and evening classes in practical welding were held there under a thoroughly competent instructor. It might fairly be said that the school had proved successful, and it had been found impossible to cope with the demand for admission to the evening classes. Profiting by the experience gained in connection with the classes at the Northern Polytechnic, the Association had adopted a method by which they could help in the formation and working of such classes in technical schools in Birmingham, Cardiff, Liverpool, Manchester, Leeds, Newcastle, Glasgow, etc. It was suggested that each should become a local centre, not only for instructing welding students, but also for investigation of many interesting points which were always cropping up in connection with oxy-acetylene welding, and also for reading and discussing papers, under the auspices of the Association.

The Newcastle and District Branch of the British Foundrymen's Association held their first annual dinner on May 31, when there was a representative gathering, under the presidency of Mr. R. Wallis, of Wallsend. Though it was only formed last year, the Branch is in a healthy and vigorous condition, with a membership of 85. The toast of "The Association" was proposed by Mr. E. Smith, who said that the organisation existed for the mutual benefit of the members. He outlined what was being done in the way of educational work—lectures, visits to various works, classes at Armstrong College, etc., all of which were helping to bridge the gulf between the scientific and the practical—to make them scientific as well as practical men. Mr. R. Buchanan, the first President of the Association, responded to the toast. He mentioned that the Association's membership was now over a thousand. They were making an impression on the engineering world in a way they had never done before. He had been told by foundry masters that there was a difficulty in getting boys for the work. The Council were taking this matter up, and intended to submit a scheme by which to attract the proper class of lads, and more of them. Their ideas ran on educational lines, and when the time came for them to promulgate their scheme, they would require all the help they could get from the Unions on the one hand, and the employers on the other. It was obvious that if there was to be a dearth of skilled workmen in the foundries, there would also be a crisis in the engineering trade generally. Mr. J. Weir (Vice-Chairman) proposed "The Visitors," and response was made by Professor Louis, of Armstrong College. He emphasised the necessity of keeping the scientific side of their work before them. Referring to the course of lectures at Armstrong College, he said that anything they could do there to help iron founders would be gladly done. The President of the Branch (Mr. R. Wallis) was afterwards toasted, and in reply referred to the able services of the Branch Hon. Secretary, Mr. H. A. J. Rang.

The third provincial meeting of the British Engineers' Association has been held at Newcastle to introduce Capt. T. C. Fitzhugh, M.V.O., the newly-appointed Commissioner of the Association in China, to members and prospective members. Mr. Clarence Smith, who presided, said the Association was formed little more than a year ago to try to protect British engineering interests in various parts of the globe. They had commenced with China, because they believed it would be one of the largest markets in the world, but they hoped to extend the scope of their operations to other parts. They had to realise that Germany and America had already organised to secure as much of the work as they could. Sir Benjamin Browne, in welcoming the visitors, expressed his appreciation of the value of the Association, but remarked that the iron and steel work required in China would provide work for this country as well as the U.S.A. and Germany if each got its fair share. In the words of one of the greatest steel-makers in this country, only one-tenth of the human race had so far been taught to use iron and steel. If another tenth were taught to use it, the existing plants of the world could not meet the demand. Mr. W. H. Dixon, of Hadfield's, Limited, said that individual efforts to get Chinese work were expensive and unsatisfactory, but an organisation which could speak authoritatively for the trade of the country could do much better. There were already demands in China for better roads, tramways, and electrical machinery, and more miles of railway had been constructed in China in the last five years than in the rest of the world. Capt. FitzHugh, dealing with the situation in China, said the Young China party were largely imbued with American ideas, while the Germans had for years spent money to press their interests in China. In addition to these two nations, others exerted a system of co-operation by insisting that contracts paid for by loans shall go to the country providing the loan. The British Engineers' Association had now been officially recognised by the Foreign Office, and lists of its members would be in the hands of every Consul in China. For the Association to be of use, it must become a national Association, and membership of it would save hundreds of pounds a year in the maintenance of special representatives in China. A similar meeting has also been held at Birmingham.

Deaths.

THE death is announced of Mr. J. Rothwell, ironfounder, of Church, near Accrington, aged 38 years.

MR. D. TAYLOR, a director of the Glossop Ironworks Company, Limited, Surrey Street, Glossop, died recently at the age of 70 years.

THE death is reported of Mr. Wm. Walkington, engineer, of the St. Alban's Works, 34, Cowper Mount, Leeds, at the age of 77 years.

MR. H. HALL, a director of John Hall & Son (Oldham), Limited, Union Ironworks, Crossbank Street, Oldham, has died at the age of 44 years.

MR. JOHN H. LIDSTONE, engineer and iron and brassfounder, of the Kingsbridge Ironworks, Duke Street, Kingsbridge, Devon, died recently, at the age of 82 years.

MR. J. G. FIEGEHEN, senior partner in the firm known as the Bedford Engineering Company, Houghton Road, Bedford, died recently at the age of 62 years.

THE death is reported of Mr. J. Mitchell, proprietor of the business of John Mitchell & Company, makers of engineers' tools, Godley Ironworks, Godley Road, at the age of 70 years.

THE death has occurred of Mr. W. Truswell, head of Messrs. Wm. Truswell & Son, ironfounders, of the Durham Foundry, Harleston Street, East Carlisle Street, Sheffield, at the age of 75 years.

MR. H. GANDERTON, proprietor of the business of Shutt & Ganderton, malleable ironfounders, 138, Suffolk Street, Birmingham, has died at the age of 89 years. The business will be continued by his son, Mr. T. H. Ganderton.

MR. J. T. COLLINS, son of the late Mr. James Collins, who founded the business of James Collins, brassfounder, Cumberland Street, Birmingham, and 20, Bartlett's Buildings, Holborn Circus, London, E.C., died recently, aged 86 years.

THE death is announced of Mr. L. Levy, a partner in Messrs. George Cohen, Sons & Company, old-iron merchants, of the River Lea Ironworks, Canning Town, and 600, Commercial Road, London, E.C. The deceased gentleman was also associated with the Shipbreaking Company, Limited and the South Wales Metals Company, Limited.

THE death occurred on June 10 of Mr. Edward Wadham, at his residence, "Millwood," near Barrow-in-Furness, at the advanced age of 85 years. Mr. Wadham was closely associated with the early history of Barrow, and together with the late Sir James Ramsden, the late Mr. H. W. Schneider, and the late Mr. J. T. Smith, iron masters, had much to do with the opening up of the iron and steel industry in Barrow. He was connected with the Barrow Hematite Steel ompany, Limited, for many years, and for some years was one of the directors. He was also a director of the North Lonsdale Iron and Steel Company, Limited, and was also connected in its early days with the Barrow Steel Castings Company.

THE death has occurred, at the age of 79 years, of Lord Rendel, who was well-known as Mr. Stuart Rendel. Born on July 2, 1834, Lord Rendel was the son of an eminent engineer, and himself became interested in engineering, and joined the board of Sir W. G. Armstrong Whitworth & Company, Limited. As a member of the Armstrong & Whitworth Committee, which sat from 1861 to 1863, he witnessed one of the most exhaustive series of experiments in artillery practice on record. Lord Rendel's father was an engineer of great eminence, the constructor, among many other works, of the harbours of Portland and Holyhead. He was brought up, as it were, in an atmosphere of engineering. From an early age he was acquainted with Lord Armstrong. It was Mr. Rendel, senior's, encouragement which led Lord Armstrong—then Mr. William Armstrong—to persevere in his artillery inventions, and to start works for the purpose of putting them in concrete form. Lord Rendel's elder brother was associated with Lord Armstrong in this enterprise while Lord Rendel was still at Oxford. When, therefore, Lord Rendel had left the University, and Lord Armstrong had completed his inventions, the two Rendels joined Lord Armstrong in starting the works at Elswick on a very extended plan. For many years Lord Rendel managed the interests of the firm in London, and acted as its representative. In 1880 he retired altogether from the partnership; but when the undertaking was transformed into a limited company, in 1883, under the name of Sir William G. Armstrong & Company, he re-entered it as a director, subsequently becoming vice-chairman ot the concern.

Personal.

MR. J. A. RICHARDS has been elected managing director of the Summerford Iron Company, Limited, of Falkirk.

THE late Mr. T. Ramsay, of Messrs. Ramsay Bros., engineers and iron founders, Whitehaven, left estate valued at £4,998 gross.

THE gross value of the estate of the late Mr. F. Foster, of Messrs. Foster Bros. & Company, Hope Foundry, Preston, is £12,775.

MR. A. A. BENNETT, secretary to Ransomes & Rapier, Limited, Waterside Works, Ipswich, has retired after 44 years' service with the company.

THE late Mr. C. W. Lyon, head of the firm of Messrs. C W. Lyon & Company, engineers, of Thornhill Lees, Dewsbury, left estate valued at £10,003 gross.

MR. W. B. H. DRAYSON has resigned his seat on the board of J. Tylor & Sons, Limited, but the directors do not propose to fill the vacancy for the present.

THE late Mr. C. P. Kinnell, chairman of C. P. Kinnell & Company, Limited, engineers and ironfounders, left estate valued at £28,198 gross, with net personalty £25,472.

MR. R. JAMES, engineering instructor at the Battersea Polytechnic, has been appointed senior lecturer in mechanical engineering at the South Wales and Monmouthshire School of Mines at Treforest.

THE late Mr. E. J. W. Teale, of 8, Calthorpe Road, Edgbaston, Birmingham, general manager for James Cartland & Sons, Limited, brassfounders, of which firm he was also a director, left estate valued at £3,066 gross, with net personalty £2,660.

MR. EDGAR A. NEWTON, of the Nine Locks Iron Works, Brierley Hill, and the London Ironworks, Smethwick, and Mr. Derry, Junr., Colmore Row, Birmingham, have joined the board of the Standard Nut and Bolt Company, Limited, Darlaston.

MR. WHARTON, of the Shelton Iron, Steel and Coal Company, Limited, Stoke-on-Trent, has been appointed manager of the blast furnace and steel works department of the Jarrow works of Palmers Shipbuilding and Iron Company, Limited, in succession to Mr. Fleming.

MR. O. STOTT, departmental manager at the works of the Alldays & Onions Pneumatic Engineering Company, Limited, of Smallheath, Birmingham, has been elected managing director of Oswald Stott, Limited, engineers, Ruskin Chambers, Corporation Street, Birmingham.

It is felt that the time has now come to recognise Mr. Andrew Carnegie's work in a worthy manner, and to give effect to this desire a committee has been formed. The committee has decided that the memorial shall take the form of a statue, to be placed in the Palace of Peace, at the Hague. It is desired to carry out the project as soon as possible, and the committee are now seeking to raise a fund for that purpose. The committee includes Sir Swire Smith (vice-chairman); the Right Hon. Sir William Mather, Mr. F. Maddison (Hon. Secretary); Mr. J. Allen, the Right Hon. Thomas Burt, M.P., Mr. Arthur Cooper, Sir Robert Hadfield, Mr. J. E. Hargreaves, and Lord Weardale.

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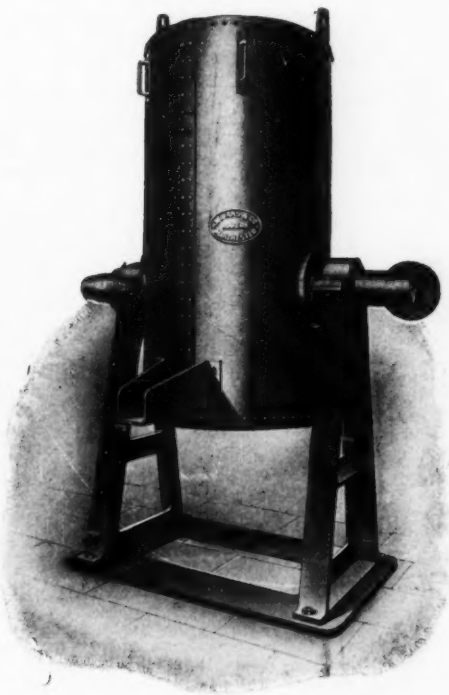

James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

New Companies.

ROTARY ENGINEERING COMPANY, LIMITED.—Capital £3,000 in £1 shares.

WILLESDEN FOUNDRY AND ENGINEERING COMPANY, LIMITED.—Capital £6,000 in £1 shares.

WILD BROTHERS, LIMITED.—Capital £3,000 in £1 shares, to carry on the business of engineers.

BEATSON & COMPANY, LIMITED.—Capital £3,000 in £1 shares, to carry on the business of engineers.

RELIANCE (COVENTRY), LIMITED.—Capital £5,000 in £1 shares, to carry on the business of metal founders.

JOHN BURGOINE & SONS, LIMITED.—Capital £3,000 in £1 shares, to carry on the business of engineers.

J. T. ROTHWELL & COMPANY, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of boilermakers.

PRIEST & MULLINGS, LIMITED.—Capital £2,000 in £1 shares. Registered office: Avondale Ironworks, Nethan Road, Bristol.

TRUEMAN ENGINEERING SUPPLIES, LIMITED.—Capital £1,000 in £1 shares. Registered office: 8, Victoria Street, Liverpool.

LANCASHIRE BRASS FOUNDERS LIMITED.—Capital £5,000 in £1 shares. Registered office: Audley Works, River Street, Blackburn.

JAMES FRYER, LIMITED.—Capital £15,000 in £10 shares, to carry on the business of engineers. Registered office: Aubrey Street, Hereford.

CHEETHAM & HILL, LIMITED.—Capital £7,000 in £1 shares, to carry on the business of engineers. Registered office: Sun Foundry, City Road, Derby.

PRESTON ENGINEERING COMPANY. LIMITED.—Capital £1,000 in £1 shares. Registered offices: Charing Cross Chambers, Duke Street, Adelphi, London, W.C.

BRYANT AND STENNER, LIMITED.—Capital £1,000 in 950 ordinary shares of £1 each and 1,000 deferred shares of 1s., to carry on the business of brass founders.

GARRETT HARTLEY & COMPANY, LIMITED.—Capital £1,500 in £1 shares, to carry on the business of engineers. Registered office: Morena Street Works, Catford, S.E.

W. S. MANUFACTURING COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of engineers. Registered office: 15, Summer Road, Birmingham.

W. N. BERRY & COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of engineers. Registered office, 32, Queen Street, Albert Square, Manchester.

S. H. MORDEN & COMPANY, LIMITED.—Capital £5,000 in £1 shares, to carry on the business of engineers' stores merchants. Registered office: 11, Tothill Street, Westminster.

M. WOLFE & COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of engineers. Registered office: 174 and 176, Great Portland Street, London, W.

WARWICK STORES, LIMITED.—Capital £5,000 in £1 shares ('2,000 preference), to carry on the business of kitchener manufacturers, etc. Registered office: 33, Chancery Lane, W.C.

CYCLOPS FOUNDRY AND PATTERNMAKING COMPANY, LIMITED.—Capital £25,000 in £10 shares, to carry on the foundry and iron works known as the Cyclops Foundry, formerly carried on by James M'Ewan & Sons, Limited, Glasgow.

BRITANNIA TUBE COMPANY, LIMITED.—Capital £100,000 in £1 shares, to take over the business of tube manufacturers, carried on by H. Huggins and F. Huggins, at the Britannia Tube Works, Glover Street, Birmingham, as William Huggins and Sons.

G. P. WINCOTT, LIMITED.—Capital £15,000 in £1 shares, to take over the business carried on by G. P. Wincott, at 180, Attercliffe Road, Sheffield, and to carry on the business of engineers, furnace builders, iron-founders, smiths, smelters, coalmasters, patent fuel manufacturers, etc.

BENTON BROTHERS, LIMITED.—Capital £10,000 in £1 shares (5,000 preference), to take over the business of a German silver and brassfounder, carried on by A. Benton at Rodley Lane Foundry, Sheffield, as Benton Brothers. The first directors are A. Benton, sen. (chairman and governing director), T. Benton, and A. Benton, jun. Registered office: 15, Rodley Lane, Sheffield.

F.T.J. Bookshelf.

Liquid Steel

By David Carnegie and Sidney C. Gladwyn. London: Longmans, Green & Company, 39, Paternoster Row, E.C.

The complex considerations which enter into the manufacture of iron and steel products to-day, the various distinct processes and their own variations, all tend to render the treatment of the subject in text books a very difficult matter. Most authors hitherto, largely by reason of the extensive field involved, have been content to give simply concise (though often instructive) surveys of the different processes. In a few cases considerable attention has been given to the technical and chemical details of the processes, but the economic side of the manufacture of steel has been largely neglected. This has been partly the result of the lack of definite data and the great difficulty of making accurate comparisons. In the book before us, however, the authors have circumscribed the range covered by their work, but have compensated by giving much fuller particulars within that range. In this respect we might say the book stands alone. We do not hesitate to affirm that it will prove extremely valuable to the steel maker, and will, moreover, meet with keen appreciation from all who have intimate connection with the manufacture of steel. To some extent the authors follow the procedure usual in text books of this character, and, starting after the pig-iron is made, consider all processes for manufacturing steel and the appliances used in connection therewith. They do not, however, deal with the further handling of steel after it is tapped from the furnace The authors have therefore taken only one section of the industry—and a very important section—as their subject. The book is divided into five parts, the first dealing with the crucible process, the second with the Bessemer process, the third with the open-hearth process, the fourth with the electric processes, and the fifth with costs and labour. The illustrations call for a word of commendation, for they have apparently all been specially prepared for the work. There are some 252 illustrations of this character, most of them being line drawings. The method of the authors is first to describe the process with appliances and plant used therefor, then to consider the cost of the plant required for given outputs, and finally, to deal with the costs of manufacture. No one has yet, so far as we are aware, had the temerity to deal with costs on anything like the same scale as the authors. The fact is that costs vary so much in different works and in different localities that it is very difficult to state figures which can be accurately applied to the industry as a whole. Nevertheless, the authors have managed to collect a vast amount of useful information which will be of very great value indeed to steel makers. No doubt, so far as costs are concerned, the authors will come in for a good deal of criticism, but it must be remembered that the difficulties of dealing with costs are great, and we may unhesitatingly affirm that this difficult part of the subject has, on the whole, been dealt with in a manner which is very worthy of commendation. A book of this class is sure to take a permanent position amongst our reference works on steel, and as such it will undoubtedly prove invaluable.

ELDER'S FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time. We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO. Ltd., (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Copy of an actual test made by one of the principal Railway Companies as to its efficacy, the original of which can be produced for inspection if necessary :—

Description of Coke	Coke Used.			Percentage of Metal Used		Pressure of Blast in Inches.	Time Cupolasin Blast.	Average Metal Melted per hour.
	Total Metal melted down.	For Lighting up coke.	For Melting Coke	Including Lighting.	Excluding Lighting.			
	CWT.	CWT.	CWT.	LBS.	LBS.	INCHES.	H. M.	CWTS.
ELDER'S	804	14	64	10.85	8.91	16	3 17	244

Elder's Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

METALS.	End June, 1913.	End June, 1912.
Iron—Scotch pig warrants ton	*65/-	*62/9
—Middlesbro' warrants ... ton	54 6	56 11½
—W.C. M/nos Bessemer ... ton	81 6	73 6
—Stock, Middlesbrough ...tons	218,682	314,664
Copper—Chili bars GMB ton	£63 12 6	£78 7 6
—Stock, Europe and afloat tons	—	—
Tin—English ingots ... ton	£197 10 0	£212 0 0
—Straits ... ... ton	£198 0 0	£208 5 0
—Stock, London, Holland, U.S.A., and afloat ...tons	—	—
Lead—English pig ... ton	£20 15 0	£18 7 6
Spelter—Ord. Silesian ... ton	£21 0 0	£25 17 6
Quicksilver (75lb)... bottle	£7 10 0	£8 0 0
Antimony—Regulus ... ton	£31 10 0 £32 0 0	£27 0 0 £28 0 0
Aluminium—Ingot ... ton	£88 0 0 £90 0 0	£80 0 0

*Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	7 7 6	to	7 12 6
Pipes, 1½ to 2½ in.	6 12 6	to	7 0 0
,, 3 to 4 in.	6 5 0	to	6 7 6
,, 5 to 8 in.	6 0 0	to	6 2 6
,, 10 to 16 in.	6 2 6	to	—
,, 18 to 24 in.	6 2 6	to	—
Chairs	4 14 0	to	4 15 0
Floor plates (open sand)	3 10 0	to	3 12 6

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows: Heavy wrought (mixed), £2 17s. 6d.; light wrought, £1 5s. 0d.; heavy cast, £3 3s. 6d.; all per ton, f.o.b., London. Copper (clean), £60 10s. 0d.; brass (clean), £43 0s. 0d.; lead (usual draft), £19 0s. 0d.; Zinc, £17 10s.0d.; all per tondelivered merchant's yards.

Legal.

Engineering Company's Capital.

Their Lordships of the First Division of the Court of Session at Edinburgh have had presented to them a petition by Alexander Turnbull & Company, Limited, engineers and valve makers, St. Mungo Works, Bishopbriggs, Glasgow, praying for confirmation of the proposed reduction of the capital to £31,250, by cancelling paid-up capital which has been lost or is unrepresented by available assets to the extent of 12s. 6d. per share on each of the 27,000 ordinary shares which have been subscribed for and fully paid-up, and by reducing the nominal amount of the remaining 3,000 ordinary shares which have not been issued also to 7s. 6d. each. Their Lordships have ordered intimation and advertisement of the petition.

THE Shropshire Union Railways and Canal Company have issued official notice of an increase in tolls. Where the present rate does not exceed 1s. the increase is to be ½d., and not exceeding 3s. 1d. one penny. For every additional 2s. 1d. in the present rate 1d. extra is to be charged, the increase being therefore 4 per cent. Several exceptions are, however, made to the rule, for traffic between Birmingham and the Black Country and Manchester, Liverpool, and Birkenhead. Thus bedsteads will be rated 1s. 8d. higher per ton, which on the present rate of 25s. is equal to 9 per cent. The rate for iron and steel in Class C carried between the Midlands and Liverpool will be advanced 6d. per ton. The new rates come into force on July 1 next.

THE shareholders of the Deptford Engineering Company, Limited, will meet at 4, Southampton Row, London, W.C., on July 11, for the purpose of considering the liquidator's accounts, showing the manner in which the winding-up has been conducted and the property of the Company disposed of.

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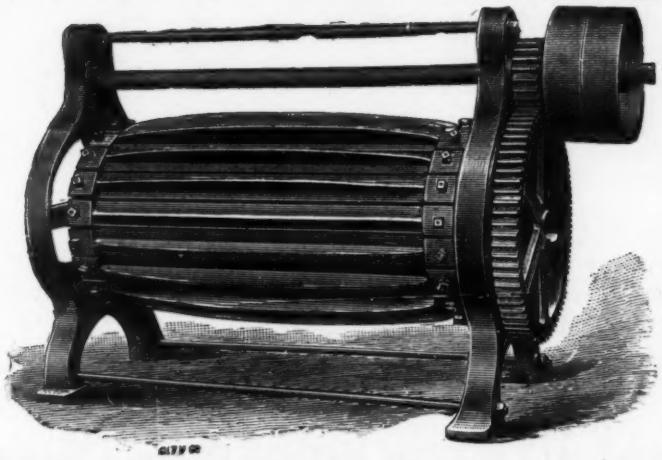

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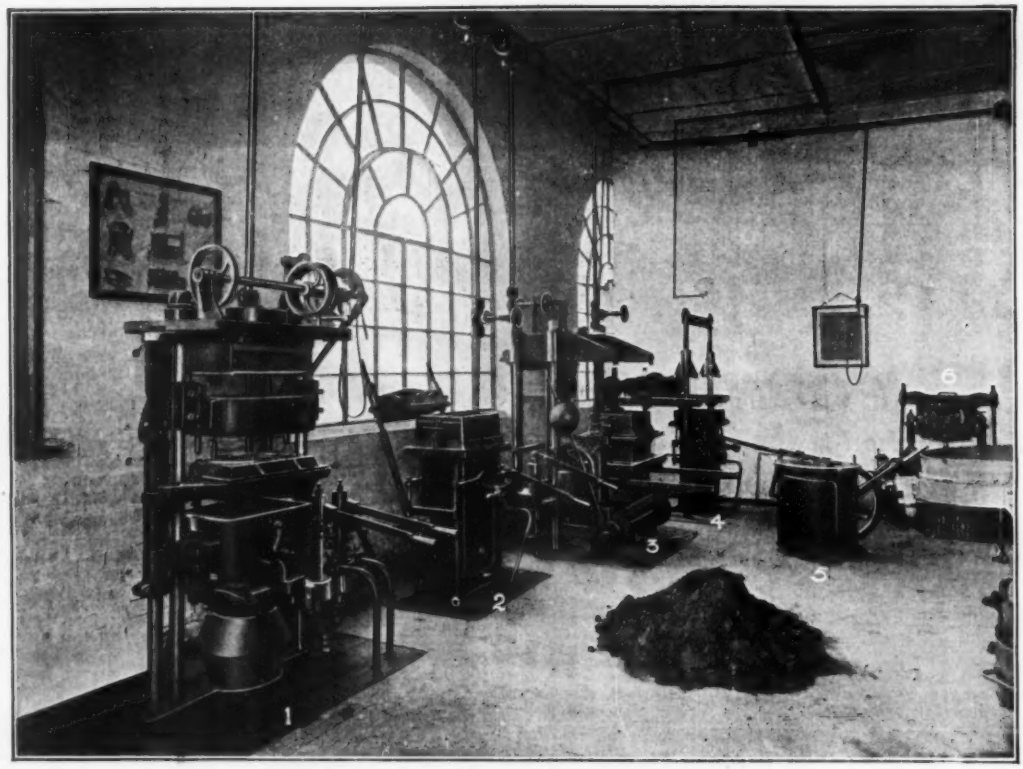

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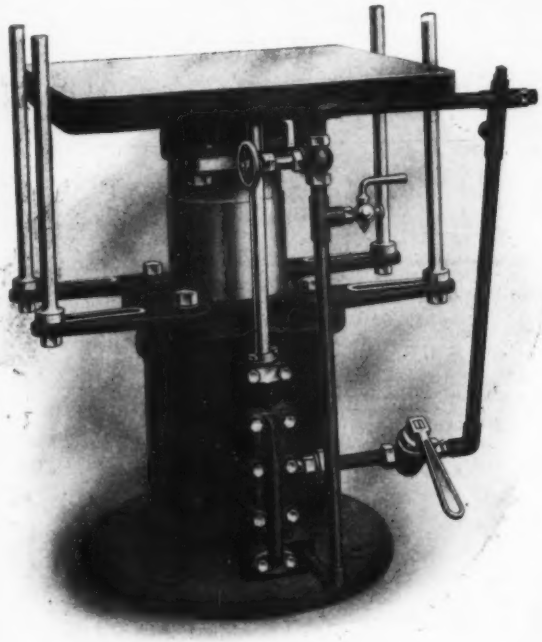

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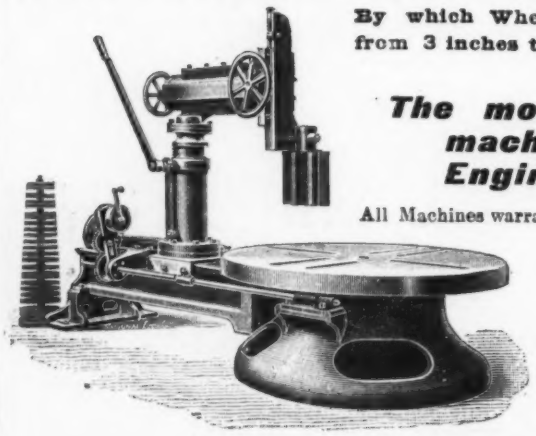

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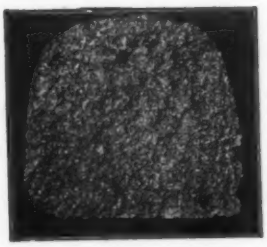
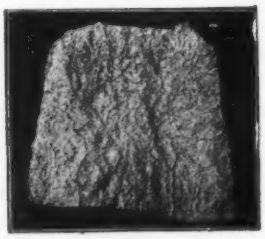
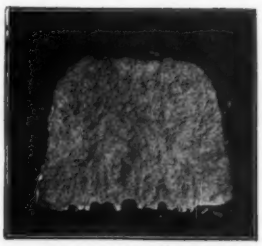

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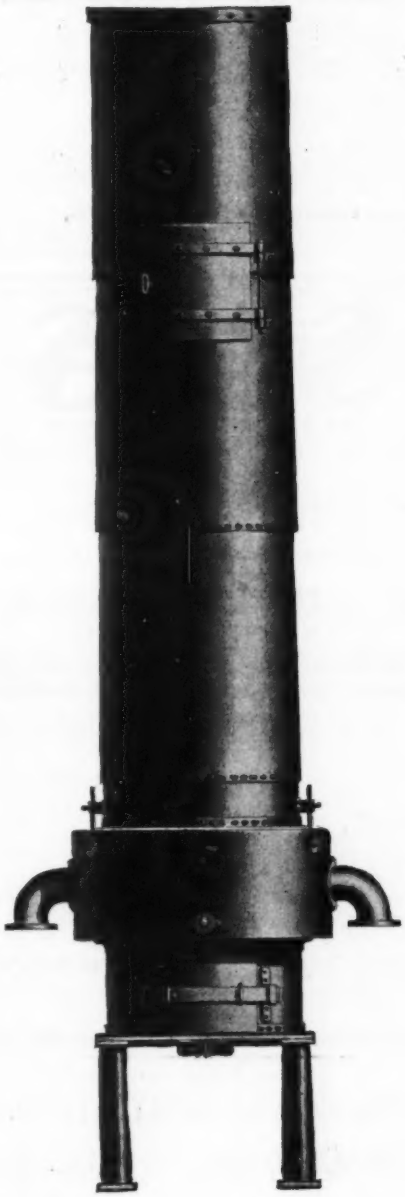

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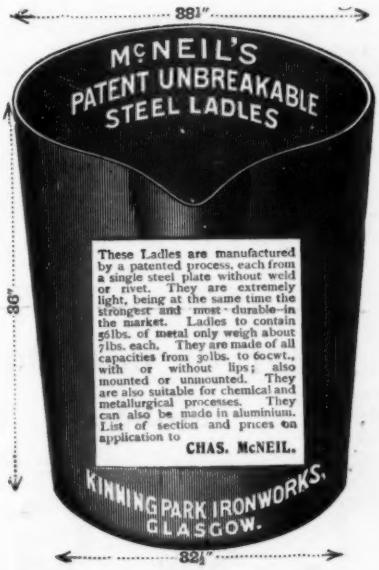
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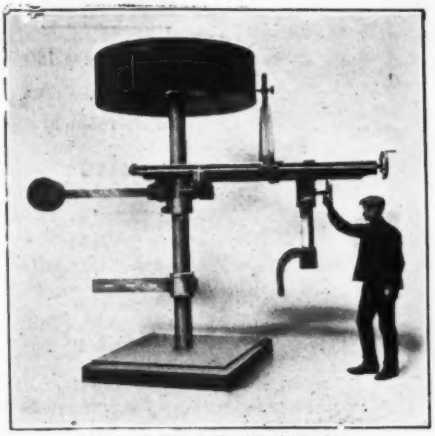

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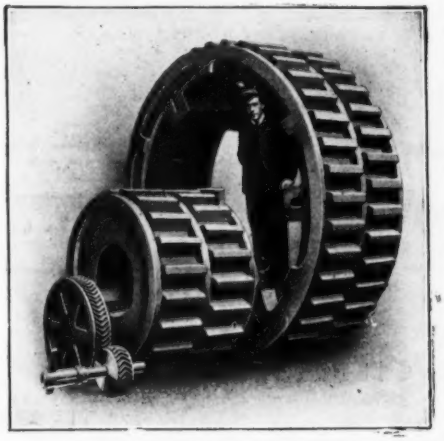

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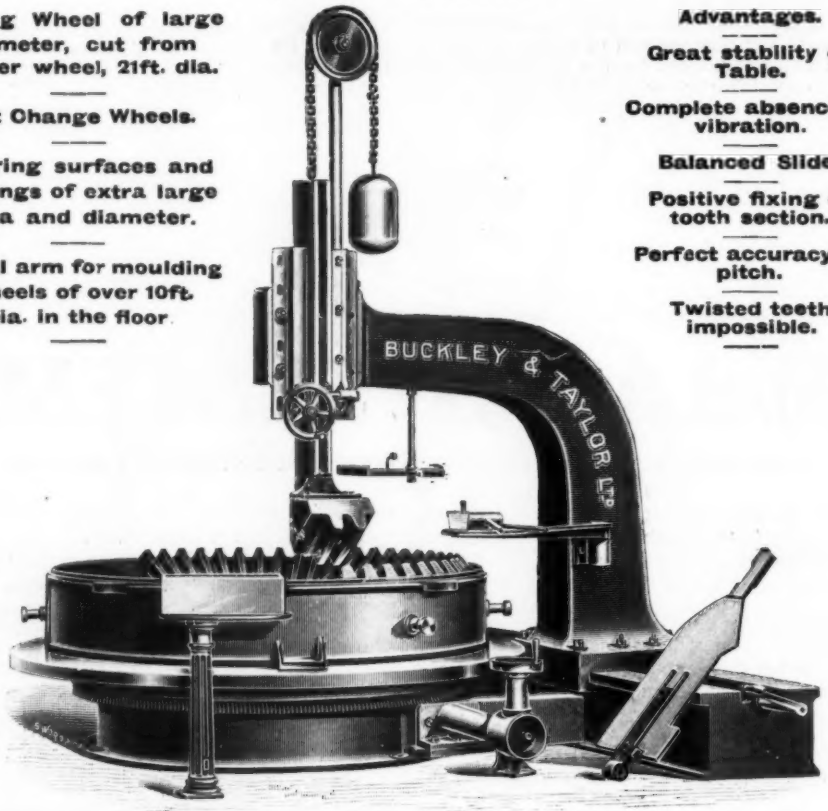

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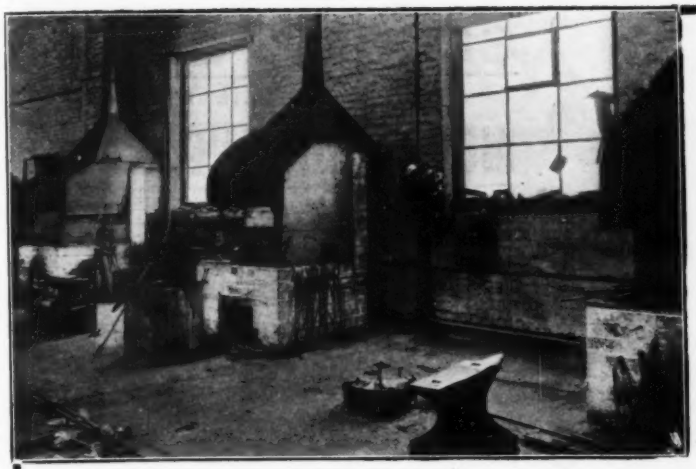

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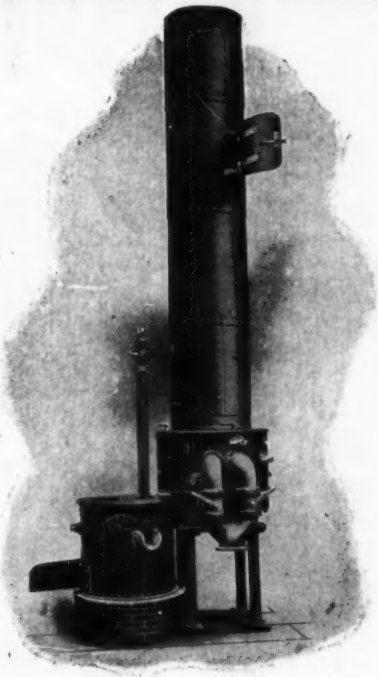

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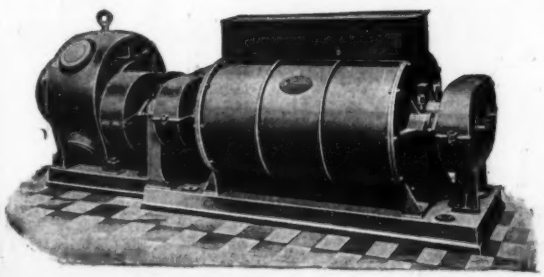

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